COUNCIL FOR GEOSCIENCE

PILOT CARBON DIOXIDE STORAGE PROJECT NEAR LEANDRA, MPUMALANGA PROVINCE

HERITAGE IMPACT ASSESSMENT

18 MAY2023

Submitted to : Nemai Consulting (Pty) Ltd

Prepared by:

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SPECIALIST ENVIRONMENTAL CONSULTING

The heritage impact assessment report has been compiled considering the NEMA Appendix 6 requirements for specialist reports as indicated in the table below.

Requirements of Appendix 6 – GN R326 EIAs Regulations (2014, amended 2017)	**Relevant section in report**
1.(1) (a) (i) Details of the specialist who prepared the report	Section 1.1.3 of Report
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Section 1.1.3 and of Report and **Appendix 2**
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page iii of the report
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 1.1
(cA) An indication of the quality and age of base data used for the specialist report	N/A
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 5
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 6
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 7
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 5.4 and 5.5, Section 6
(g) An identification of any areas to be avoided, including buffers	Section 6
(h) A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	**Appendix 1**
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 3
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Sections 6, 11
(k) Any mitigation measures for inclusion in the EMPr	Section 8, 11
(l) Any conditions for inclusion in the environmental authorisation	N/A
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	N/A
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Section 13
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and	
(n)(ii) If the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 8, 12
(o) A description of any consultation process that was undertaken during the course of carrying out the study	Not applicable. A public consultation process will be handled as part of the EIAs and EMPr process.

Requirements of Appendix 6 – GN R326 EIAs Regulations (2014, amended 2017)	**Relevant section in report**
(p) A summary and copies if any comments that were received during any consultation process	Not applicable. To date no comments have been raised regarding heritage resources that require input from a specialist.
(q) Any other information requested by the competent authority.	Not applicable.
(2) Where a government notice by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Section 38(3) of the NHRA

Declaration of Independence

The report has been compiled by Nitai Consulting (Pty) Ltd, an appointed Heritage Specialist for Nemai Consulting for the Proposed Pilot Carbon Dioxide Storage Project, near Leandra, Mpumalanga Province. The views contained in this report are purely objective and no other interests are displayed during the Heritage Impact Assessment Process.

I, Jennifer Kitto, declare that –

General declaration:

- *I act as the independent heritage specialist*
- *I will perform the work in an objective manner, even if this results in views and findings that are not favourable to the project;*
- *I declare that there are no circumstances that may compromise my objectivity in performing such work;*
- *I have expertise in conducting heritage impact assessments, including knowledge of the National Heritage Resources Act, No 25 of 1999 (NHRA), associated Regulations and any guidelines that have relevance to the proposed activity;*
- *I will comply with the NHRA, associated Regulations and all other applicable legislation, specifically the National Environmental Management Act, No 107 of 1998 (NEMA);*
- *I will take into account, to the extent possible, the matters listed in section 38 of the NHRA;*
- *I have no, and will not engage in, conflicting interests in the undertaking of the activity;*
- *I undertake to disclose to the project proponent and the competent authority all material information in my possession that reasonably has or may have the potential of influencing -any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;*
- *I will ensure that information containing all relevant facts in respect of the project is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;*
- *I will provide the competent authority with access to all information at my disposal regarding the project, whether such information is favourable to the project or not*
- *All the particulars furnished by me in this form are true and correct;*
- *I will perform all other obligations as expected of a heritage specialist in terms of the NHRA and NEMA, associated Regulations, the constitutions of my affiliated professional bodies; and*
- *I realise that a false declaration is an offence in terms of regulation 71 of the NEMA Regulations and is punishable in terms of section 24F of the NEMA.*

Disclosure of Vested Interest

I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the NEMA Regulations;

- *I realise that a false declaration is an offence in terms of regulation 71 of the Regulations and is punishable in terms of section 24F of the NEMA.*

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ACKNOWLEDGEMENT OF RECEIPT

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Executive Summary

South Africa (SA) has a coal-based energy economy and emits carbon dioxide (CO_2) into the atmosphere at approximately 400 million tonnes per year. In recognising its contribution to climate change, the country has committed itself to undertake steps to minimise such emissions. CCUS has been acknowledged by SA as one of the technologies to mitigate the emissions of CO_2 into the atmosphere and forms one of the Nationally Appropriate Mitigation Actions (NAMA). It is also one of the national flagship projects. CCUS forms part of a just transition to a future low-carbon energy economy.

The Council for Geoscience (CGS) is undertaking a geoscientific research project for the piloting of CCUS in Leandra in Mpumalanga, where it is proposed to inject CO_2 into deep suitable geological formations, approximately 1km below the surface. The Government of SA has received funding from the World Bank's International Bank for Reconstruction and Development to finance the CCUS Project.

The northern portion of the Highveld coalfields presents unique geology, which affords the potential storage of CO_2. The proposed CO2 Injection site is situated near Leandra in the Govan Mbeki Local Municipality, which falls within the Mpumalanga Province of South Africa. The proposed footprint area is located along the R29 from Leandra to Kinross and is bounded to the south by a railway line from Secunda to Springs

Methodology/ Significance Assessment

A literature review / historical desktop study was undertaken which has shown that various archaeological and historical resources could be expected to occur in the project area. The examination of the earliest edition (1965) of the 1:50 000 topographical maps produced by overlying the maps with satellite Imagery (Google Earth) has shown that a few heritage features are depicted within the CO2 Injection Site footprint.

The subsequent site survey fieldwork undertaken confirmed the findings of the desktop study and identified five heritage resources within and adjacent to the CO2 Injection Site footprint.

Identification of Activities, Aspect and Impacts

The project area that will be impacted by the proposed Pilot Carbon Dioxide Storage project is situated on portion 2 of the Farm Goedehoop 308IR. The proposed CO2 Injection site is located outside (to the northeast) of the town, between the R29 road from Leandra to Kinross and the railway line from Secunda to Springs.

The impact of the proposed project on protected historical structures is medium to low due to the presence of a historical stone railway culverts (CO-03), and two possible but not certain structure or homestead remains (CO- 01, CO- 04).

The impact significance of the project on graves and cemeteries is medium to low as a potential grave (CO-02) identified within the CO2 Injection site footprint could be affected.

The impact significance of the project on intangible and living heritage resources is negligible to low as no intangible or living heritage resources were identified.

The impact significance of the proposed project on archaeological resources is low as no archaeological sites or material were identified.

Mitigation Measures

The proposed Pilot Carbon Dioxide Storage project could impact on five heritage resources identified within or immediately adjacent to the CO2 Injection Site footprint area.

The recommendations below are provided to mitigate the potential impact of the proposed project on the identified heritage resources:

Historical structure

- **The two Historical Railway Culverts at CO-03 and CO-05** are protected by section 34 of the NHRA and must be avoided as a "no-go" area with a 20-30m buffer to prevent any indirect impact and ensure that during site clearance and construction activities these structures are not damaged
- The materials demarcating the 30m buffer must be highly visible and made of durable material to ensure that they are remain in place during the construction and operation activities

Potential Grave

- **The potential grave at CO-02**, that may be located within or on the boundary of the proposed CO2 Injection site, is protected by section 36 of the NHRA. Therefore, any site clearance activities for the proposed Injection site within 30m of the approximate location, should be monitored by a heritage specialist/archaeologist. If a burial or human remains are uncovered during site clearance or construction activities, a buffer of at least 30m must be placed around the site to ensure that the burial/human remains are not damaged. In addition, all site clearance or construction activities in the immediate vicinity of the burial/human remains must be suspended. The heritage specialist/archaeologist will then need to apply for a permit for a rescue exhumation of the burial/human remains, in compliance with section 36 of the NHRA.

Palaeontological Heritage

- The Screening Tool identified the underlying geology of the project footprint as having a Medium sensitivity for palaeontological heritage, while the SAHRIS Palaeontological Map identified the underlying geology of the project footprint as having an Insignificant to Zero fossil sensitivity. However, SAHRA has required either a desktop or a field palaeontological assessment for past HIAs in the surrounding area.

- The assessment would confirm if it is likely that significant/sensitive fossils will be impacted by the proposed project and provide mitigation measures and the way forward in this regard. The project may only proceed once the palaeontological assessment has been undertaken and any mitigation recommendations have been implemented.

Conclusion

Taking all of the above into account, the considered opinion of the heritage specialist is that no fatal flaws have been identified during this study. Therefore, there are no objections from a heritage perspective provided that the recommendations and mitigation measures contained in this report and in the palaeontological assessment are implemented where necessary.

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List of Abbreviations

APHP	Association of Professional Heritage Practitioners
ASAPA	Association of Southern African Professional Archaeologists
BGG	Burial Grounds and Graves
CGS	Council for Geoscience
CRM	Cultural Resources Management
CCUS	Carbon Capture Utilisation & Storage
DALRRD	Department of Agriculture, Land Reform & Rural Development
DFFE	Department of Fisheries Forestry and Environment
EA	Environmental Authorisation
EHS	Environmental, Health and Safety
EAP	Environmental Assessment Practitioner
EIA	Early Iron Age
EMPr	Environmental Management Programme
ESA	Early Stone Age
ESIA	Environmental and Social Impact Assessment
GIS	Geographic Information System
ha	Hectare
HIA	Heritage Impact Assessment
IAP	Interested and Affected Party
IAIAsa	International Association for Impact Assessment South Africa
IBRD	International Bank for Reconstruction and Development
IFC	International Finance Corporation
km	Kilometre (1 000m)
LIA	Late Iron Age
LSA	Later Stone Age
MPHRA	Mpumalanga Provincial Heritage Resources Authority
MSA	Middle Stone Age
NAMA	Nationally Appropriate Mitigation Actions
NEMA	National Environmental Management Act (No. 107 of 1998)
NHA	National Health Act, (No. 61 of 2003)
NHRA	National Heritage Resources Act (No 25 of 1999)
PHRA	Provincial Heritage Resources Authority
SAHRA	South African Heritage Resources Agency

1 INTRODUCTION

South Africa (SA) has a coal-based energy economy and emits carbon dioxide (CO_2) into the atmosphere at approximately 400 million tonnes per year. In recognising its contribution to climate change, the country has committed itself to undertake steps to minimise such emissions. CCUS has been acknowledged by SA as one of the technologies to mitigate the emissions of CO_2 into the atmosphere and forms one of the Nationally Appropriate Mitigation Actions (NAMA). It is also one of the national flagship projects. CCUS forms part of a just transition to a future low-carbon energy economy.

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The northern portion of the Highveld coalfields presents unique geology, which affords the potential storage of CO_2. The proposed CO2 Injection site is situated near Leandra in the Govan Mbeki Local Municipality, which falls within the Mpumalanga Province of South Africa. The proposed footprint area is located along the R29 from Leandra to Kinross and is bounded to the south by a railway line from Secunda to Springs

1.1 Scope & Terms of Reference for the HIA report

1.1.1 Summary of Key Issues & Triggers Identified During Scoping

In terms of the NHRA, the following proposed activities trigger the need for a Heritage Impact Assessment (HIA):

- Potential occurrence of heritage resources, graves and structures older than 60 years within the Project's footprint.
- Proposed development that is more than 5000m^2
- Proposed linear development that is longer than 300m
- Proposed development where an impact assessment is triggered in terms of NEMA.

1.1.2 Approach

- Undertake a Heritage Impact Assessment in accordance with the NHRA.
- Identify and map all heritage resources in the area affected, as defined in Section 2 of the NHRA, including archaeological sites on or near (within 100m of) the proposed developments.
- Assess the significance of such resources in terms of the heritage assessment criteria as set out in the regulations.
- Assess the impacts of the Project on such heritage resources.
- Prepare a heritage sensitivity map (GIS-based), based on the findings of the study.

- Identify heritage resources to be monitored.
- Comply with specific requirements and guidelines of Mpumalanga PHRA and SAHRA.

1.1.3 Nominated Specialist Details

Organisation:	Nitai Consulting
Name:	Jennifer Kitto
Qualifications:	BA Archaeology and Social Anthropology; BA (Hons) Social Anthropology
No. of years' experience:	24
Affiliation (if applicable):	Association of Southern African Professional Archaeologists (ASAPA) - Technical member No.444 International Association for Impact Assessment (IAIAsa) – Member No. 7151

1.2 Project Description

The northern portion of the Highveld coalfields presents unique geology, which affords the potential storage of CO_2. The site is situated near Leandra in the Govan Mbeki Local Municipality, which falls within the Mpumalanga Province of South Africa. The R29 runs through the central part of the overall project area. Refer to the map contained in **Figure 1** below.

The proposed CO2 Injection site is located along the R29 from Leandra to Kinross and is bounded to the south by a railway line from Secunda to Springs.. Refer to the map contained in **Figure 2** below.

2 LEGISLATION

The identification, evaluation and assessment of any cultural heritage site, artefact or find in the South African context is required and governed by various pieces of legislation, including the National Heritage Resources Act, 25 of 1999 (NHRA) and associated Regulations, National Environmental Management Act, Act 107 of 1998 (NEMA) and associated Regulations and, as well as the National Health Act, Act No. 61 of 2003 (NHA), specific Regulations governing human remains.

2.1 South African Legislation

2.1.1 National Heritage Resources Act (Act No 25 of 1999; NHRA)

The NHRA is the defines cultural heritage resources (section 3), provides protection to specific types of heritage resources (sections 34, 35, 36) and also requires an impact assessment of such resources for specific development activities (section 38(1)). Section 38(8) further allows for cooperation and integration of the management of such impact assessment between the national or provincial heritage authority (SAHRA or a PHRA) and the national environmental authority (DEFF).

In terms of section 38(1)(a) of the NHRA, the specific types of development activity that may require a Heritage Impact Assessment (HIA) include: the construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length. As the proposed CO_2 Injection Site is larger than 5000m^2, this study falls under s38(8) and requires comment from the relevant heritage resources authority. (South African Heritage Resources Authority-SAHRA and/or the Free State Provincial Heritage Authority).

Sections 34-36 of the NHRA further stipulate the protections afforded to specific types of heritage resources, *i.e*. structures older than 60 years (s34); archaeological, palaeontological, meteorites (s35); graves and burial grounds (s36), as well as the mitigation process to be followed if these resources need to be disturbed. The Project may cause impacts to any of these types of heritage resources.

2.1.2 National Environmental Management Act (Act 107 of 1998; NEMA)

NEMA states that an integrated Environment Management Plan (EMP) should, (23 -2 (b)) "…identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage". In addition, the NEMA and associated Regulations GNR 982 (Government Gazette 38282, 14 December 2014, amended 2017) state that, "the objective of an environmental impact assessment process is to, … identify the location of the development footprint within the preferred site … focussing on the geographical, physical, biological, social, economic, *cultural and heritage aspects* of the environment" (GNR 982, Appendix 3(2)(c), emphasis added).

The EIA Regulations, 2014 (as amended), published in GNR 982 of 2014 (Government Gazette 38282) promulgated under the (NEMA) contain specific requirements to be addressed in the different types or impact assessment repots (Regulations 19, 21 and 23) as well as requirements for Specialist Reports (Appendix 6).

2.1.3 The National Health Act (Act No. 61 of 2003; NHA) and associated Regulations (2013)

In the case of graves and/or burial grounds that could be impacted by a proposed development, and which are identified through an impact assessment, specific Regulations relating to the Management of Human Remains (GNR 363 of 2013 in Government Gazette 36473) address the exhumation and reburial of human remains: Regulations 26, 27 and 28.

2.2 International Requirements

The regulatory aspects dealt with above relate solely to the South African laws and regulations and would usually be the only requirements for an Environmental and Social Impact Assessment (ESIA). However, since the finance for the CCUS project was received from the World Bank's IBRD, the project must comply with the requirements of World Bank Policies & Environmental, Health and Safety (EHS) Guidelines as well as the International Finance Corporation (IFC) Performance Standards observed by most large international financial institutions. Summaries of these requirements are set out below.

2.2.1 World Bank Policies & Environmental, Health and Safety Guidelines

In addition to the above IFP requirements, the World Bank's Safeguard Policies and Environmental, Health and Safety (EHS) Guidelines were put in place to prevent or mitigate adverse impacts of its projects on people and the environment. As the proposed project is considered a Category A project, but was onboarded prior to 2018 it is thus subject to the Safeguards Policies (OPs), specifically with regard to cultural heritage OP/BP 4.11 - Physical Cultural Resources. This Operating Policy specifically requires that the physical cultural resources component of the Environmental Assessment includes (a) an investigation and inventory of physical cultural resources likely to be affected by the project; (b) documentation of the significance of such physical cultural resources; and (c) assessment of the nature and extent of potential impacts on these resources. This OP also requires that when the project may have adverse impacts on physical cultural resources, the ESIA includes appropriate measures for avoiding or mitigating these impacts.

2.2.2 The International Finance Corporation

The IFC Performance Standards (PS) are an international benchmark for identifying and managing environmental and social risk and have been adopted by many organizations as a key component of their environmental and social risk management. The IFC's Environmental, Health, and Safety (EHS) Guidelines provide technical guidelines with general and industry-specific examples of good international industry practice to meet the IFC's PS.

In many countries, the scope and intent of the IFC PS are addressed or partially addressed in the country's environmental and social regulatory framework. The IFC PS encompass eight topics of which PS 7 and PS 8 have direct relevance to heritage resources. PS 7 and PS 8 relate to Indigenous Peoples and Cultural Heritage respectively.

Standard (PS) 8 – Paragraph 9 (Consultation) (2012) refers to the need for consultation with affected communities to identify cultural heritage of importance and involve affected communities and the relevant national or local regulatory authorities in the decision-making processes.

Standard (PS) 8 – Paragraph 12 (Removal of Non-Replicable Cultural Heritage) (2012) states that the removal of cultural heritage must only be considered when no other alternative is available.

3 ASSUMPTIONS AND CONSTRAINTS

This assessment assumes that all the information provided by the client and the Environmental Assessment Practitioner (EAP) regarding the project footprint is correct and current.

Firstly, given the nature of the present project, a Pilot Research project, there are uncertainties associated with the limitations of knowledge and previous research studies. Nevertheless, it is underlined that there are several uncertainties associated, among others, with upscaling to an industrial-scale CO2 injection, particularly in the context of fracture-controlled reservoir permeability. Secondly, another uncertainty factor that could potentially generate changes in the impact assessment is associated with the likelihood of CO2 leakage occurring throughout the CCS process. However, it is considered that, overall, the current level of knowledge is adequate for the assessment of the main environmental impacts of the project, providing an appropriate framework for the conclusions of this report and for decision-making by the competent authorities.

Regarding the heritage impact field survey it should be noted that the injection site and immediately surrounding area was covered in extremely dense and long vegetation which meant that archaeological and heritage visibility was low in those areas. In addition, it was noted that two roads had been graded through the topsoil along the northern and eastern boundaries of the injection site. Therefore, there is a possibility that some heritage resources were not identified, specifically, informal graves or burial sites.

4 PROJECT DESCRIPTION

4.1 Location

Mpumalanga Province is a prime mining area with intensive mining and petrochemical activities and thus is the area with the most prevalent CO2 emissions in the country. As stated, this factor, along with the identification of suitable geological formations, makes the town of Leandra the identified location for the Project.

The northern portion of the Highveld coalfields presents unique geology, which affords the potential storage of CO2. The CO2 Injection Pilot site is located just outside (north-east) of Leandra, in Govan Mbeki Local Municipality - a semi-urban municipal area consisting of farms and urban settlements - in Gert Sibande District Municipality, region of Mpumalanga Province, South Africa.

The R29 runs through the central part of the overall project area. Leandra town is situated adjacent to the major gold and coal mining areas of Evander and Secunda respectively, about 120 km to the east of Johannesburg. Refer to the map contained in **Figure 1** below.

The proposed CO2 Injection site is located along the R29 from Leandra to Kinross and is bounded to the south by a railway line from Secunda to Springs. The site footprint is situated on portion 2 of Farm Goedehoop 308. Refer to the map contained in **Figure 2** below.

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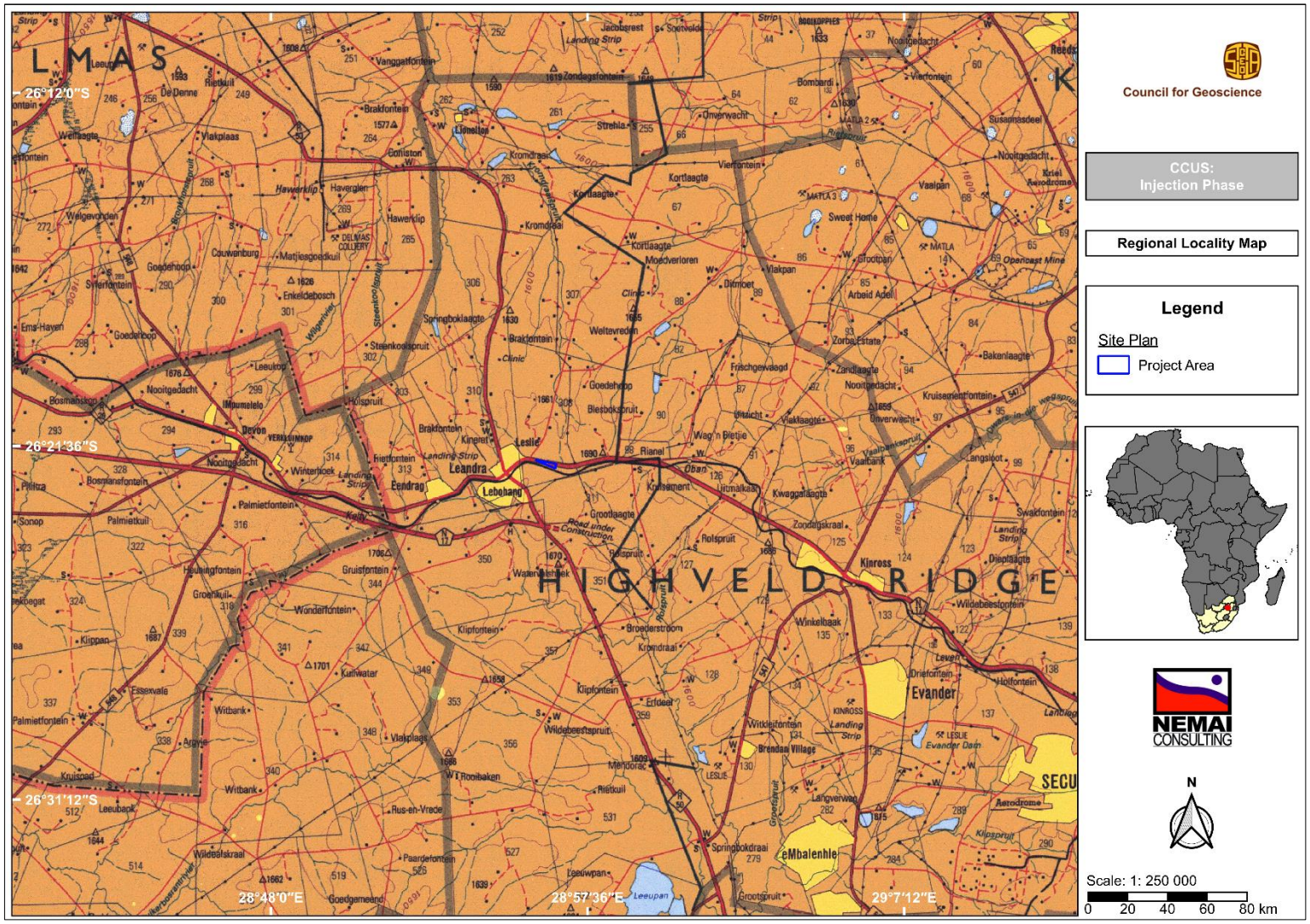

Figure 1: Regional Location of Proposed CO_2 Injection Pilot Project Site (blue polygon)

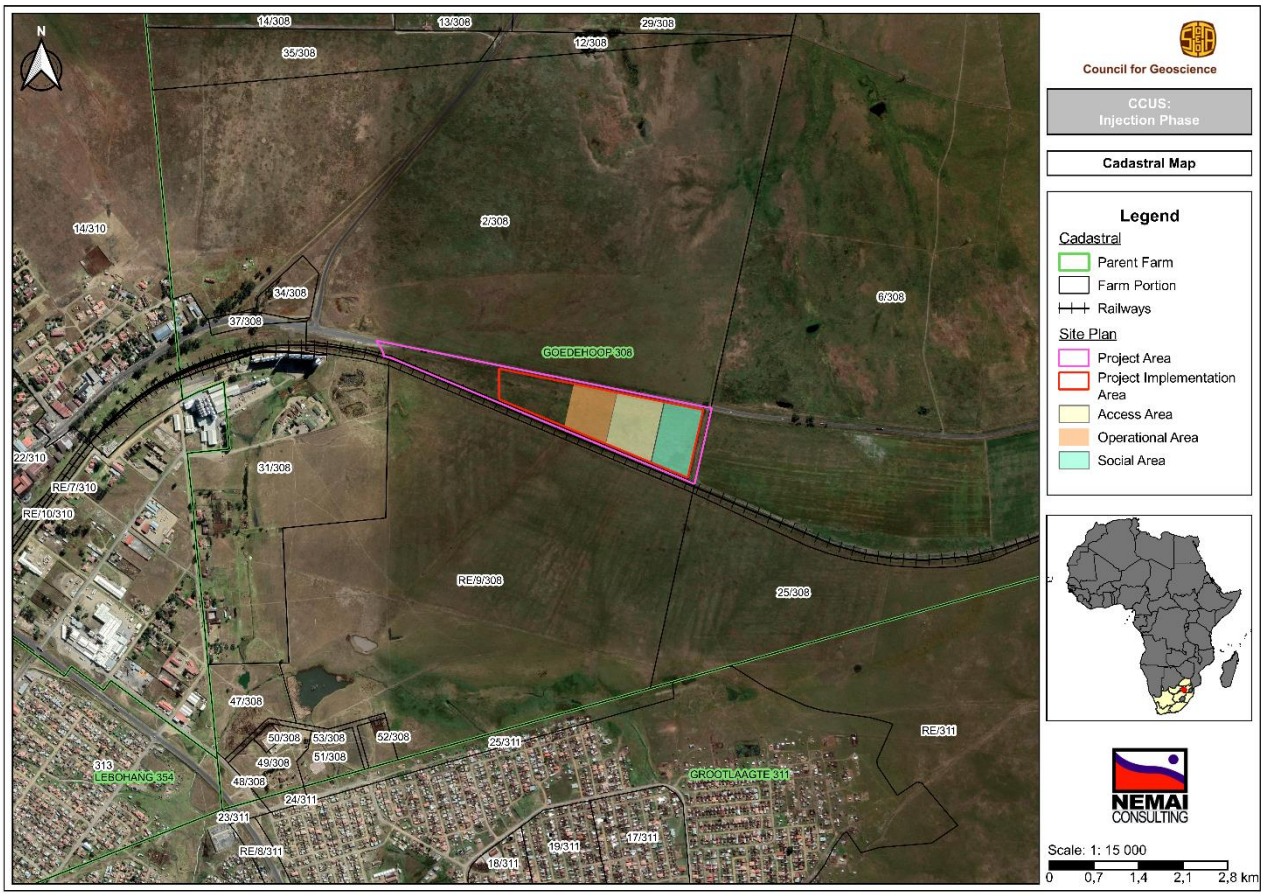

Figure 2:Proposed Site Layout of the CO2 Injection Site footprint

Project Areas:

Based on the Project location, Table 1 outlines the areas considered for ESIA:

Table 1: Project Areas for the assessment

Area Typology	Units	Details
Project Property Area	14 ha	Chosen property area for the development of the project
Project Implementation Area	10ha	Area within the project property, considered as useful area for the Project Implementation (also considering road and railway safety distances)
Direct Area of Influence	Buffer of one kilometer	Area to which it is considered that impacts may be felt directly
Indirect Area of Influence	Buffer of five kilometers	Area to which it is considered that impacts may be felt indirectly

It is noted that, although the environmental and social assessment considers these areas as the baseline, the direct and indirect areas of influence can be adjusted according to the subject under assessment.

4.2 Pilot CO2 Storage Project description

4.2.1 Introduction

Coal is the major energy source in South Africa and responsible for a great part of Carbon Dioxide emissions. According to the World Bank data, in 2015, energy production from coal sources accounted for 92.7% of the total electricity produced in South Africa (World Bank, 2022c) and more recently, coal comprised 65% of the primary energy supply in 2018 (Mineral Resources & Energy Department, 2021). With more than two-thirds of energy generation capacity based on coal resources, the largest is produced within Mpumalanga Province (Council for Geoscience, 2021). Furthermore, in 2019 the CO2 emissions (in metric tons per capita) recorded a value of 7.6, which is in line with the values that have been recorded since 2015 (World Bank, 2022d) and placing South Africa as the top CO2 emitter on the African continent and one of the top emitters globally. On the other hand, the Climate Policy of South Africa is rooted in the principles of the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol and has ratified the Paris Agreement. Therefore, the Government is committed to reducing CO2 emissions up to 50% in the next 10 years and to enable a sustainable transition toward a low-carbon economy (Council for Geoscience, 2021). Despite being the leading CO2 emitter, one of the country's commitments is the implementation of climate changes mitigation measures (Nemus 2023). Carbon Capture, Utilization, and Storage has been recognized as one of the technologies to mitigate the emissions of carbon dioxide into the atmosphere - in particular within areas with a large coal reliance (like Mpumalanga) - and forms one of the Nationally Appropriate Mitigation Actions (Council for Geoscience, 2022).

4.2.2 Project aim

Overall, the Project aims are the:

- Construction and operation of the Pilot CO2 Storage Project, through the implementation of CCS technology;
- Investigation and characterization of a suitable CO2 storage site and subsequent injection, storage, and monitoring into deep geological formations;
- Injection and storage between 10,000 to 50,000 tons of CO2; and,
- Understanding the viability of the Mpumalanga Province area as a suitable site storage

4.2.3 Need and Desirability

At the present stage of technological development, the South African economy is supported by a large scale coal-based energy system, being one of the largest coal producers globally (Nemus 2023). In this context of an inevitably CO2 emissive energy production matrix, the Republic of South Africa has established a set of Nationally Appropriate Mitigation Actions (NAMA) to minimize greenhouse gas emissions. These measures are aligned with the targeted measures to reduce CO2 emissions by more than half in the next 10 years (Nemus 2023). The NAMA include the possibility of Carbon Capture, Utilization, and Storage (CCUS). CCUS is one tool for a just transition to a low-carbon energy system, by storing CO2 that would otherwise accumulate in the atmosphere in suitable deep geological formations. The Council for Geoscience has been mandated to provide for the promotion of research and the extension of knowledge in the field of geoscience, as well as the provision of specialised geoscientific services. Therefore, possible geological storage options have been explored as a technological possibility of Carbon Capture and Storage. Specifically, the stated purpose of the CCS Project is the assessment and the demonstration of the application of CCS technology to South African conditions and to build technical capacity. Generally, the northeast of South Africa is the region with the most coal reserves highlighting the presence of intensive mining and petrochemical industrial activities, and thus where the most CO2 emissions occur, being thus a potential region for the CCUS implementation. Additionally, although the CCUS investigations typically consider deep saline aquifers, relatively deep coal seams, and depleted oil and gas fields as potential storage reservoirs, more recently assessments and investigations are being carried out into the possibility of CO2 storage in basaltic sequences of the Ventersdorp Supergroup (Nemus 2023). The combination of these characteristics (presence of mining and petrochemical industrial activities and a basaltic geological nature) resulted in the Mpumalanga Province being identified as suitable for the implementation of the present Project.

4.2.4 General characteristics

CO2 Capture and Storage is a technically feasible method, studied over several years, for reducing carbon dioxide emissions from sources such as combustion of fossil fuels, as in power generation, and the preparation of fossil fuels, as in natural-gas processing (Nemus 2023).

Overall, the technology is based on the utilization or storage of CO2 in suitable deep geological formations, leading to a reduction in the anthropogenic release of CO2 into the atmosphere.

The process includes three key stages:

1) Capturing CO2 from anthropogenic sources;
2) Transportation to the injection site;
3) Permanent geological storage or utilization of the CO2.

The present Project is a test of this application, specifically considering the storage of CO2 (Council for Geoscience, 2022). With the purpose of assessing the Project environmental and social risks and impacts and "the feasibility of and to build expert capacity for carbon capture and storage" (Council for Geoscience, 2022) overall, the Project activities include the site establishment, drilling and construction of an injection well of approximately 1,800 metres, road transportation, and operation/injection of CO2 at the designated site.

To understand the framework, the characteristics of the Project to be assessed - location justification, main activities to be undertaken, timeframe and project phases - are outlined below.

4.2.4.1 Location

The location choice is based on the following main factors:

- The Mpumalanga Province has the presence of coal-fired stations, and mining and petrochemical industrial activities that are identified as responsible for high levels of CO2 emissions, being the Project area nearby a major polluter (highlights include the Eskom Power Plants and the Sasol Secunda Refinery);
- The Project area is characterized by a basaltic geological nature with Storage potential;
- The Project area is under the ownership of the Gert Sibande District Municipality and currently without any human use; and,
- The site location fulfils the main factors that led to the selection of the preferred site.

4.2.4.2 Project Activities

Following the Project aims, and the Project Implementation Area, **Figure 3** represents the Project site plan, including social, access and operational area. The site plan was developed to ensure the development of the activities in a structured and safe manner (a 50-metre buffer to the injection site has been defined, and the entire area will be fenced).

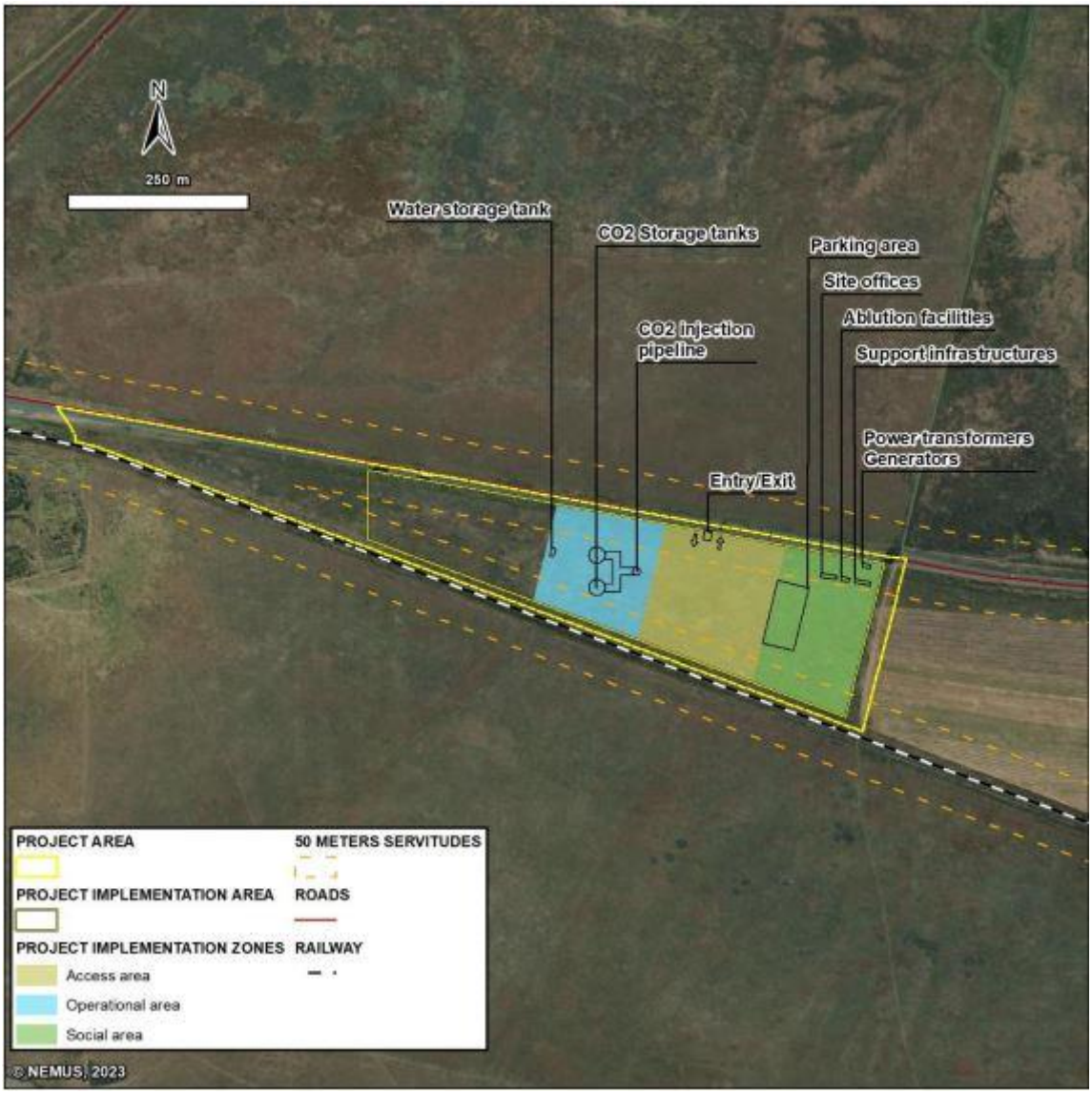

Figure 3: CO2 Injection Site Proposed Layout

5 STATUS QUO ANALYSIS

5.1 General Existing Condition of Receiving Environment

The general project footprint is situated over portion 2 of the Farm Goedehoop 308IR. The proposed injection site project area is located just outside Leandra town to the north-east on municipal land that is currently vacant and situated between the R29 road from Leandra to Kinross and the railway line from Secunda to Springs. The injection site will be fenced for safety and security purposes.

The project footprint is situated in a semi-urban area with farms and urban settlements, in an altered and artificialized Grassland Biome due to commercial and subsistence crop cultivation, large- and small-scale mining, human settlement and urban physical infrastructure (Council for Geoscience, 2022).

The Project area general topography is considered to be flat, with the superficial geological layer consisting of Dolerite. The Ventersdorp Supergroup, in which Ultramafic lava is integrated, is the target for the CO2 storage since the constituent rocks are sources of Magnesium (Mg) and Calcium (Ca) and thus susceptible to promptly react with CO2 (via both injection technologies). Moreover, the chosen site is considered to fulfil the geological characteristics of a potential reservoir, with Diamictite the sealing layer.

Figure 4: View of the CO_2 Injection Site footprint area looking west, showing the railway, long dense grass, and a recently graded road

Figure 5: General View of the area immediately South of the proposed CO_2 Injection site

Figure 6: View immediately Southwest of the proposed CO_2 Injection Site looking towards the town of Leandra

Figure 7: View of the area immediately north of the CO2 Injection Site footprint, looking northwest to Leandra town

Figure 8: View of the area immediately north of the CO2 Injection Site footprint, looking towards the R29 road

5.2 Cultural-Heritage Receiving Environment

5.2.1 DFFE Environmental Screening Tool

The DFFE National Environmental Screening Tool was accessed for information on the cultural-heritage sensitivity of the general region and the injection site project footprint specifically. The information from the Screening Tool indicates that the Archaeological and Cultural sensitivity is indicated as being Low (**Figure 9**), while the Palaeontological sensitivity is indicated as being mostly Medium for the presence of fossils (**Figure 10**).

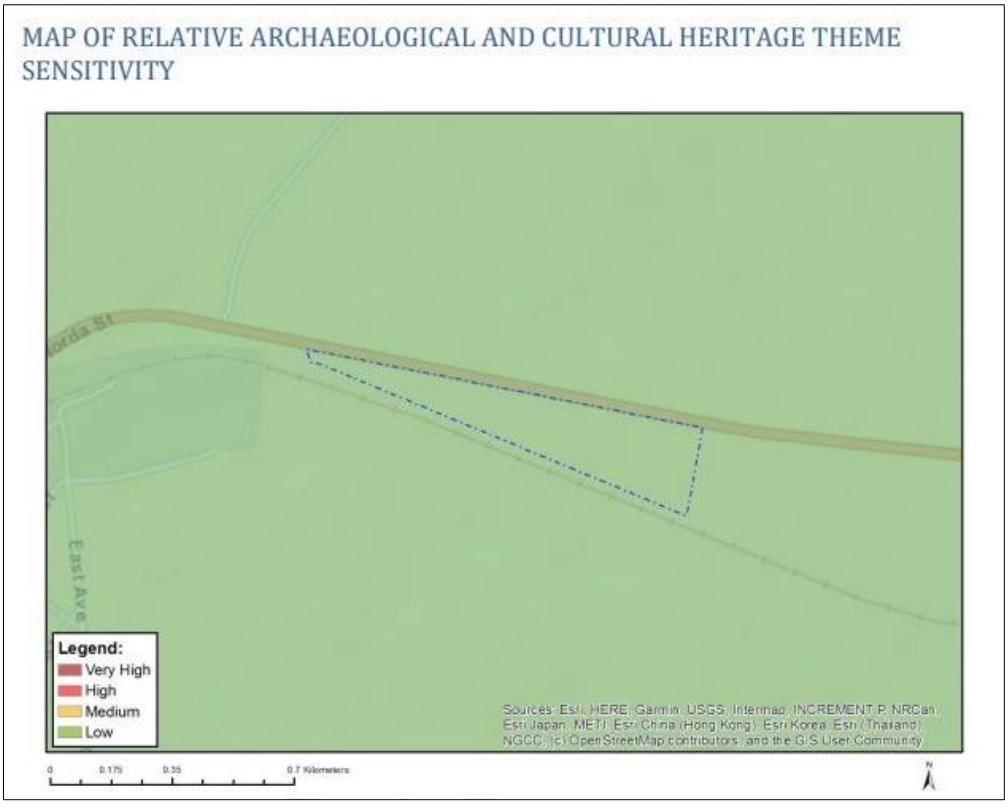

Figure 9: Archaeological Cultural Sensitivity map indicating that the project footprint is located within a region of low heritage sensitivity (DFFE Screening Tool).

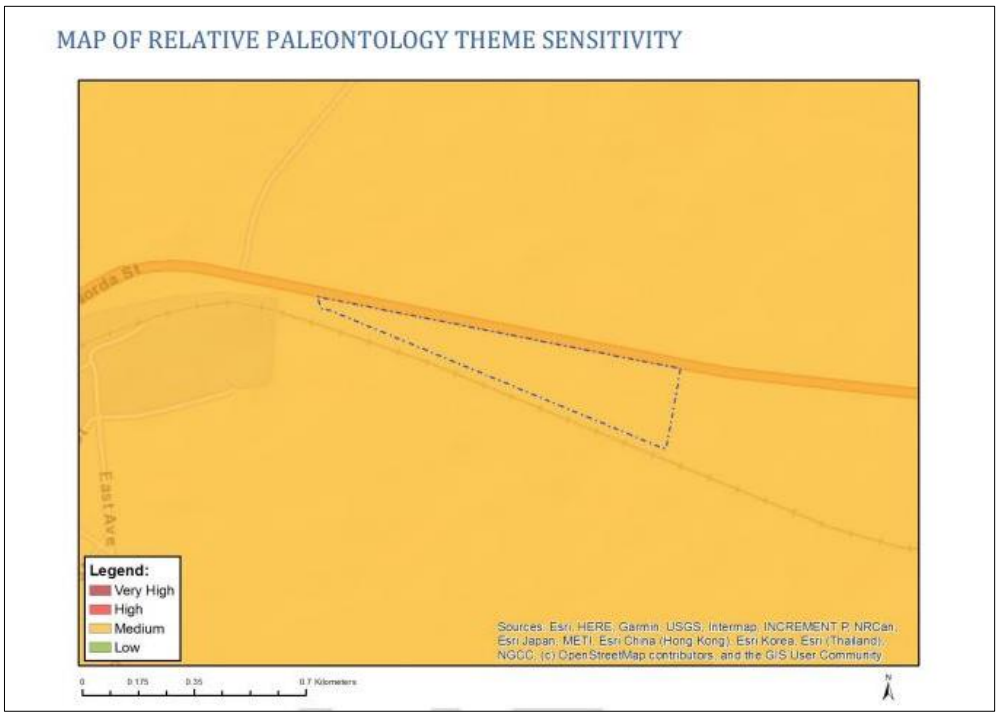

Figure 10: Palaeontological Sensitivity map indicating that the project footprint is located within a region of Medium sensitivity (DFFE Screening Tool).

5.2.2 Historical Background of Surrounding Region (archaeological and historical literature survey)

The archaeological history of the area can broadly be divided into a Stone Age, Iron Age and Historic or Colonial Period. An archaeological and historical overview of the general region is presented below.

The Stone Age

In South Africa the oldest archaeological period is referred to by archaeologist as the Earlier Stone Age (ESA). The ESA dates from about 2 million to 250 000 years ago. The ESA comprises two technological phases. The earliest of these is known as Oldowan, after Olduvai Gorge in Tanzania where the stone tools were first recognised in the 1960s (Esterhuysen and Smith, 2007). This phase is associated with simple flakes and hammer stones. It dates to approximately 2 million years ago. The second technological phase is the Acheulian (named after a site in France where they were first discovered in the 1800s), which comprises more specialised stone artefacts such as the cleaver and bifacial hand axe. The Acheulian dates to approximately 1.5 million years ago.

The Middle Stone Age (MSA) is associated with a definite change in the technique used to produce stone tools from *circa* 250 000 years ago. The new technique produced flakes, points and blades from a prepared core. The attaching of stone tools onto bone or wood shafts to produce spears, knives or axes is also associated with the MSA (Esterhuysen and Smith, 2007). This phase is also associated with modern humans and complex cognition (Wadley, 2013). Although not much research has been undertaken on the MSA in Mpumalanga, the Bushman Rock Shelter (BRS) on the farm Klipfonteinhoek in the Ohrigstad District is a well-known site with occupation layers dated to between c.40 000 years ago to c.27 000BP (Esterhuizen and Smith, 2007). No Early Stone Age sites are known in the direct vicinity of the study area.

The Later Stone Age (LSA) is the third archaeological phase, which occurred from about 20 000 years ago, and is marked by further technological changes and social transformations. The technological changes include the production of very small stone tools called microliths; the bow and the link-shaft arrow; stones with holes bored through the middle which were used as digging-stick weights; polished and decorated bone tools; ostrich eggshell beads and the production of rock paintings and engravings. Evidence of ritual practices and complex societies is also significant (Deacon & Deacon 1999). This period is associated with both hunter-gatherers (San) and early pastoralists (Khoekhoe). It continued until the arrival of Iron Age farming groups and European settlers (including a period of interaction). Two LSA sites are known on the farm Honingklip near Badplaas in the Carolina District. They are located on opposite sides of a bend in the Nhlazatshe River, in the foothills of the Drakensberg (Esterhuysen and Smith, 2007; Delius (ed) 2006). No Middle Stone Age sites are known in the direct vicinity of the study area.

Rock Art

Several rock painting sites are known from the greater region: including Carolina (10), Ermelo (8), Middleburg (1) and Witbank (4). No engraving sites are known (Smith and Zubieta, 2007). A recent research study by Maseko (2020) has identified 31 rock painting sites in the area around the towns of Hendrina, Breyten, Lake Chrissie and Carolina.

The Iron Age

The Early Iron Age (EIA) in South Africa begins from c.AD 500 until c.AD1100. This period is associated with the migration of Bantu-speaking farming communities into the Mpumalanga region and the continued movement of such communities between the Lowveld and Highveld of Mpumalanga until the 12th century (Esterhuysen and Smith, 2007). These people practised a mixed farming economy and had the technology to work metals like iron and copper.

The Late Iron Age in South Africa (AD 1600 – AD 1840) is associated with pre-colonial farming communities (both agricultural and pastoralist), who lived in distinctive and often extensive stone-walled settlements (to which Huffman has given the label, 'Central Cattle Pattern') (Delius 2006; Huffman, 2007). The general area between Carolina and Lydenburg contains a large number of LIA settlements which indicates a substantial increase in population or movement of people into the area from the 15th century (Esterhuysen and Smith 2007).

Esterhuysen (2008) notes that according to early historians like Van Warmerlo and Jackson, the Southern Ndebele descended from Chief Musi or Msi, who originated in the Drakensberg or Kwa-Zulu Natal area but at some point between 1650 and 1700 certain branches of the group moved away and settled north of Pretoria.

Two main groups or periods (distinguished by ceramic styles) have been identified by Huffman (2007) as occurring in the general region: Uitkomst and Buispoort. The Uitkomst subgroup (facies) of the Blackburn Branch of the Urewe Ceramic Tradition represents the first Iron Age period to be identified in this general area. The decoration The decoration on the ceramics seems to be combine characteristics associated with both Nguni-speaking and Sotho-speaking groups. This subgroup is thought to date between AD 1650 and AD 1820. The Buispoort facies of the Moloko branch of the Urewe Ceramic Tradition is the next phase that has been identified in this area. It is thought to date between AD 1700 and AD 1840. (Huffman, 2007). However, no sites associated with either ceramic style is known from the study area.

Historical/ Colonial period

Skhosana (2010) notes that according to the earliest researchers the Transvaal Ndebele were understood as being an Nguni group which originated in what is now KwaZulu-Natal where they belonged to the Hlubi people. The group that became known as the Transvaal Ndebele are the descendants of the same ancestral chief, commonly known as Musi. This group seems to have parted from the main Nguni body sometime between the 16th and 17th centuries and settled in the area around modern day Pretoria, in the vicinity of Bon Accord. Skhosana further relates that a subsequent succession struggle between Musi's five or six sons around the turn of the 19th century resulted in the original group splitting into two main groups, known as the Northern Ndebele and the Southern Ndebele, respectively, which then fragmented further. Nzunza and his brother Mthombeni, together with their followers, moved eastwards before settling in an area in the vicinity of the present day town of Belfast, in the then Transvaal. Mthombeni and his followers subsequently moved northwards towards Zebediela where they eventually settled. Another son, Manala and his group occupied the land northeast of Pretoria which is now known as Wallmansthal.

During the 18th and 19th century the existing groups in the general region were disrupted by the expansion of the Zulu Kingdom and subsequent displacement of the population, which became known as the Difaqane/Mfecane (Makhura, 2007). In the north-eastern area, the Pedi under King Thulane, became dominant, until they were defeated by the Ndebele group of Mzilikazi. This resulted in the existing Sotho tribes moving out of the area (Kitto, 2015).

Historical/Colonial Period

The vacuum resulting from the Difaqane/Mfecane was subsequently filled by Swazi groups under the reign of King, Sobhuza, who established various small chiefdoms in the Mpumalanga area (Bonner, 1983; Makhura, 2007).

The earliest traveller who came to the area was Robert Scoon in 1836; while the earliest Voortrekker party to cross over the Vaal River was the one under the leadership of Louis Trichardt and Johannes Jacobus Janse van Rensburg. Between 1841-1850, there was an increasing presence of Voortrekkers in the general vicinity of the study area (Bergh, 1999). This resulted in Mswati II of the Swazi/Swati people ceding the southern Transvaal to the colonial system (Bonner 1983).

In 1845, both the district and town of Lydenburg were established (Bergh, 1999). The district of Lydenburg was extremely large and it seems that the study area fell just within this district.

The South African War (1899 – 1902) was fought between the Boer Republics of the Transvaal and Free State on the one side and Great Britain on the other, but the victims and participants of the war were not limited to British or Boer citizens alone. No events or activities during the war can be associated with the Leandra area. However, at least one battle from the surrounding landscape is known. This was an engagement between a British force under the command Lieutenant-General J.D.P. French and a Boer commando of some 1 000 men on 23 July 1900. The main component of this engagement occurred a short distance to the east and south-east of the present-day town of Delmas, which is located some 35km northwest of Leandra (Changuion, 2001). The local Boer families in the area, as well as the African population, were also affected by the policy of the British which resulted in their removal from their farms to one of the two concentration camps establishment at Middelburg and Standerton (https://www2.lib.uct.ac.za/mss/bccd/).

The present day town of Leandra/Lebohang was formed from the almalgamation of the former villages of Eendrag and Leslie. The name is a combination of Leslie and Eendrag (Raper 2014; Erasmus 2014). The village of Leslie was originally laid out on the farm Brakkefontein and proclaimed in December 1939. A later extension was proclaimed in December 1957. Raper states that the name is thought to be taken from a town called Leslie in Scotland, UK. The small village of Eendrag, was formerly called by the Dutch/Afrikaans name Eendracht, which means ‘unity’ and apparently relates to the motto, “Eendrag maak mag” or “Unity is strength”(Raper 2014).

Recent/ Modern History

The Manala and Nzunza Ndebele groups, lived separately until the late 1970s, when the so-called "bantustan" of KwaNdebele was created under the "homeland system" of the apartheid government This caused extreme disruption to the local African communities in the area (Skhosana 2010; SA History online).

During the 1980s, Leandra became a symbol of defiance against the forced removals policies of the previous *apartheid* administration. Since the 1970s, there had been many attempts to forcibly move the residents of Leandra to the so-called "independent homeland" of KwaNdebele. Although the attempt in the early 1980s was to move a portion of its residents, the majority of the people of Leandra stood up to halt these forced removals. Under the leadership of the Leandra Action Committee (LAC), the community demanded that the entire population be allowed to remain. On the 7th June 1984, the Leandra Community and LAC received a letter through their lawyers from the Ministry of Co-operation and Development which stated that the 116 families who had been threatened with removal would be reprieved and would not be expected to move to KwaNdebele. (TRAC 1985).

5.2.3 Cartographic findings

An assessment of available historical topographical maps was undertaken to establish a historic layering for the study area. Overlays of the maps were made on Google Earth. These historic maps are valuable resources in identifying possible heritage sites and features located within the study area. It should be noted that the earliest edition of the map sheets for this area dates to the 1960s. As the first edition of this sheet dates to 1965, it was not considered necessary to examine the later edition map sheets. Any heritage resources that are 60 years or older would be depicted on the 1965 edition sheet. The topographical maps were obtained from the Department of Agriculture Land Reform and Rural Development (DALRRD) in Cape Town.

The following 1:50 000 South Africa topographic map sheet was assessed for the CO2 Pilot Project Injection site footprint: 2628BD Leslie Edition 1 1965. The map was surveyed in 1965 and drawn in 1966 by the Trigonometrical Survey Office of the Republic of South Africa from aerial photographs taken in 1948.

As can be seen in **Figure 11,** below, the 2628BD Edition 1 1965 map sheet depicts one heritage feature within the CO2 Injection Site footprint area, which is a grave. Several homestead clusters or single homesteads are depicted in the area north of the R29 road, while no heritage features are depicted in the area immediately south of the injection site footprint.

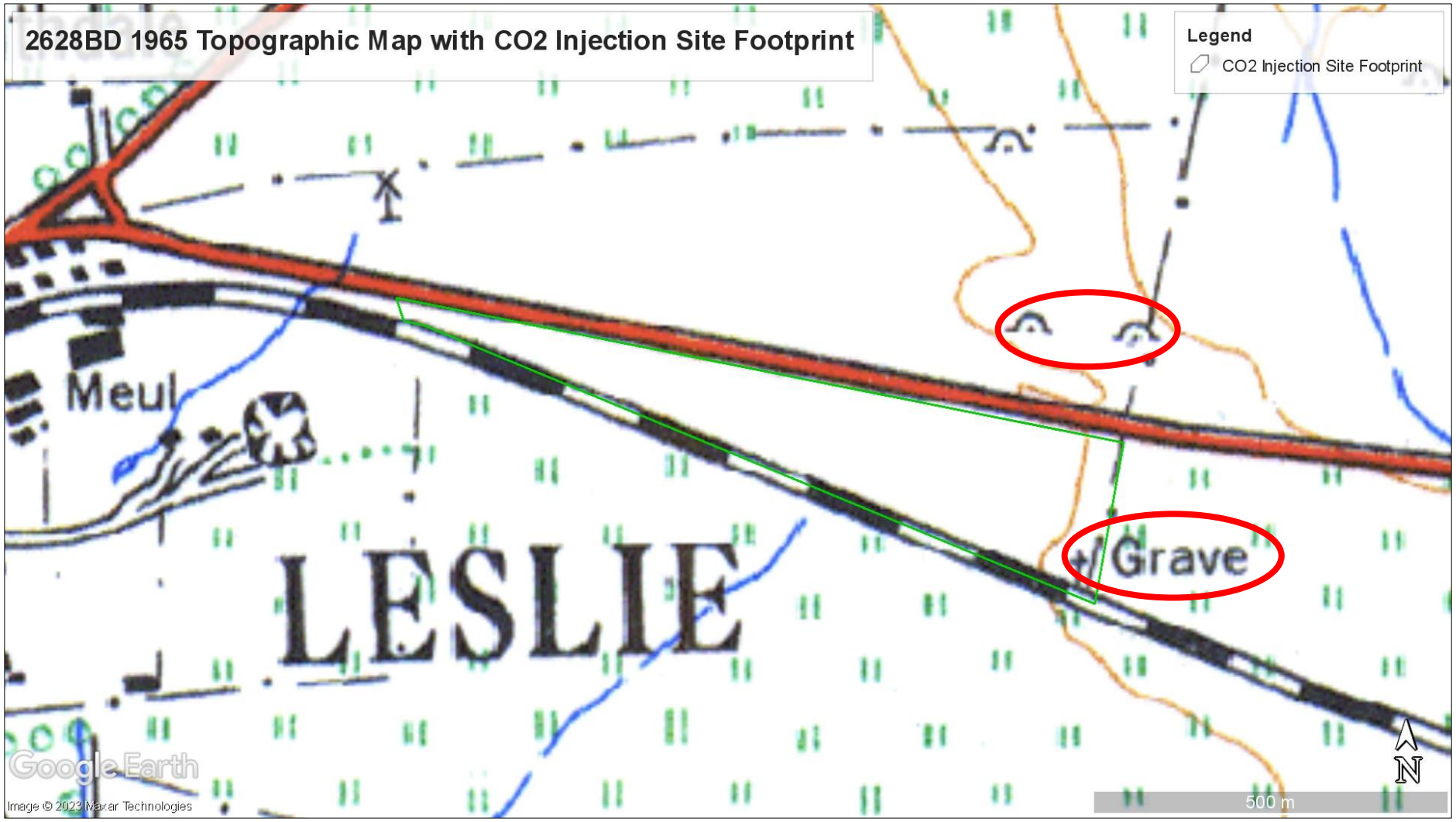

Figure 11: Enlarged view of topographic map 2628BD Ed 1 1965, depicting one heritage features within the CO2 Injection Site footprint (green polygon). Several homestead clusters or single homesteads are depicted in the area immediately north of the R29.

5.3 Previous HIA reports in the area

A search on the South African Heritage Resources Information System (SAHRIS) has identified several Heritage Impact Assessments conducted in and around the study area. The project area of three of these reports covered areas in the immediate vicinity of the town of Leandra: Kusel 2011, Pistorius 2016 and Smeyatsky & Fourie 2918. Other HIA reports contained information on the general surrounding region.

Kusel, U. 2011. *Cultural Heritage Resources Impact Assessment For Portion 29 of the Farm Goedehoop 308IR Govan Mbeki Local Municipality Mpumalanga Province.* The HIA study was for the proposed development of a truck yard. The survey did not identify any heritage resources on the property. A modern farmhouse and new infrastructure for large trucks, workshops and offices as well as a diesel depot had been constructed.-

Pistorius, JCC. 2016. *A Phase I Heritage Impact Assessment (HIA) Study for Anglo Operations (Pty) Ltd's Proposed Leslie 2 Project (near Leandra) in the Gauteng Province*. The survey identified two historical farmstead complexes and six informal graveyards (each containing approx. 20 -40 graves), as well as one possible grave.

Smeyatsky I and W Fourie, 2018. *Heritage Impact Assessment: Proposed Leslie Coal Mine near Leandra, Mpumalanga Province.* The HIA study identified 31 sites consisting of 22 burial sites (with a total of approximately 315 graves), one (1) living heritage (initiation) site and eight (8) historical structures.

Van der Walt, J. 2021. *Heritage Impact Assessment (Required Under Section 38(8) Of The NHRA (No. 25 of 1999) For The Proposed Leandra Gravel Mine on a Portion of Portion 4 of the Remaining Extent of the Farm Brakfontein, Mpumalanga Province.* The study found no heritage features of significance (archaeological, built environment or graves).

Pistorius, J. 2020. *A Phase I Heritage Impact Assessment Study for the Shondoni and Middelbult Mining Areas near Secunda in the Mpumalanga Province.* The Sasol Project Area stretches from Leandra in the northeast towards Secunda and Trichardt and in the south-east incorporating the Sasol petro-chemical complex near eMmbalenhle. This study found a large number of historical remains consisting of farmstead complexes, houses and other historical structures, graveyards, and commemorative beacons.

Pistorius, J.2013. *A Phase I Heritage Impact Assessment (HIA) Study for a Proposed Raw Water Supply Pipeline For Kipower (Pty) Ltd Near Delmas on the Highveld and Eastern Highveld in the Gauteng and Mpumalanga Provinces of South Africa*. This study investigated the proposed pipeline between Delmas Coal to the south of the R50 on the farm Haverklip 256IR and Eendrag, close to Leandra. The study identified four graveyards and an historical house that dated to the 1940s

5.4 Palaeontological sensitivity

Note that this section was compiled by the author and not by a palaeontological specialist. A basic palaeontological sensitivity was determined using the SAHRIS database South African Palaeontological Sensitivity Map (http://www.sahra.org.za/sahris/map/palaeo). This map indicates that the project footprint falls within an area where the underlying geology has Insignificant to Zero fossil sensitivity (grey) (see **Figure 12** below). However, during the SAHRIS database search it was noted that SAHRA had requested either a desktop or a field Palaeontological assessment for several of the projects proposed for the surrounding region. Since this project will involve the injection of CO_2 into the existing bedrock, it is likely that either a desktop or a field palaeontological assessment study will be required by SAHRA. The SAHRIS Palaeontological Sensitivity differs from the Screening Tool indication of Palaeontological Sensitivity which is rated Medium.

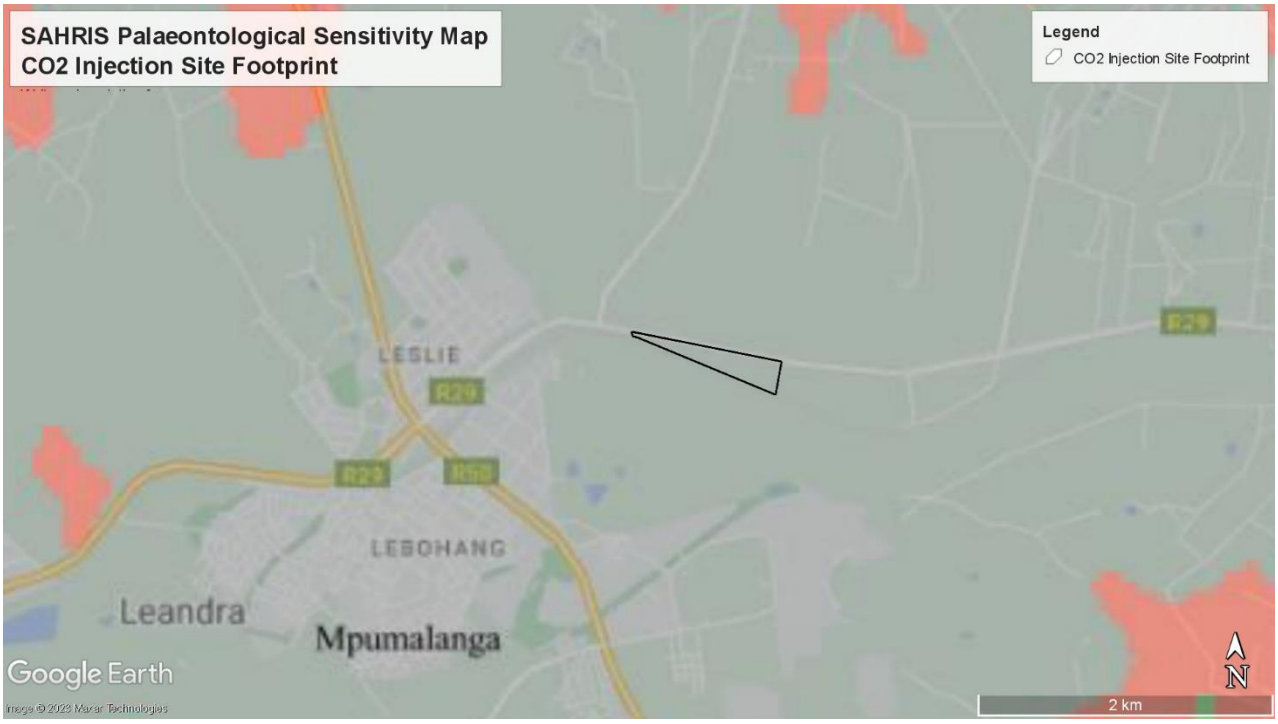

Figure 12: SAHRIS Palaeo sensitivity map overlain on the project footprint (black polygon). The underlying geology is shown as mostly of Insignificant to Zero fossil sensitivity (grey).

Table 2: SAHRIS Fossil Map Palaeontological Sensitivity Ratings and Required Actions

Colour	Sensitivity	Required Action
RED	VERY HIGH	Field assessment and protocol for finds is required.
ORANGE/ YELLOW	HIGH	Desktop study is required and based on the outcome of the desktop study, a field assessment is likely to be requested.
GREEN	MODERATE	Desktop study is required.

BLUE	LOW	No palaeontological studies are required however a protocol for finds is required.
GREY	INSIGNIFICANT /ZERO	No palaeontological studies are required.
WHITE/CLEAR	UNKNOWN	These areas will require a minimum of a desktop study. As more information becomes known, SAHRA will continue to populate the map.

5.5 Findings of the Historical Desktop Study

The general overview from the historical desktop study has shown that various archaeological and historical resources can be expected to occur in the general region of the project area. The examination of the earliest edition (1960) of the 1:50 000 topographical maps produced by overlying the maps with satellite Imagery (Google Earth) has shown that a few heritage features are depicted within or immediately adjacent to the CO_2 Injection project footprint.

The Site Survey fieldwork confirmed the findings of the desktop study as it identified five heritage resources occurring within or adjacent to the immediate project area footprint (CO_2 Injection site).

6 SITE SURVEY/FIELDWORK RESULTS

The survey of the Pilot Carbon Dioxide Project Site (which included the direct area of influence) took place over one day (9 February) by the author (heritage specialist) as part of a specialist team. A vehicle was used to access the general project region and the survey was conducted by both vehicle and on foot (at selected areas). The proposed Injection Drilling Site footprint was covered on foot.

The survey covered as much of the general and specific project areas as was feasibly accessible, given the presence of long dense grass and other vegetation covering most of the areas. It should be noted that most of the existing town of Leandra is included in the area of direct Influence.

The author used a Global Positioning System (GPS) application to navigate access roads in the study area and for recording the tracklog of the survey and waypoints of the identified heritage resources. A combination of a Sony digital camera and a Samsung mobile phone camera was used for photographic recording of identified heritage resources and general images of the project study area.

The survey aimed to find and identify archaeological and other heritage resources such as burial grounds and graves (BGG), archaeological material or sites, historic built environment and landscape features of cultural heritage significance. The survey of the project site identified five heritage resources within the immediate area of the Injection Site footprint (**Figure 23**).

Identified Heritage Sites – Proposed CO_2 Injection Site

Site Name	CO-01
GPS Coordinates	26°22'13.09"S ; 28°56'34.33"E
Site Description	Possible homestead
Approximate Age	Unknown. Nothing is marked at this location on the maps from 1965, up to
NHRA, No. 25	Section 34
Field Grading and Ratings	
Site context and description	The site comprises a clear, open area with much shorter grass and vegetation and contains various scattered clusters of stones. It is located immediately south of the proposed injection site, across the railway line, approx. 27m away from the railway line.
Site Density	Unclear
Uniqueness	Low
Heritage Significance	Low- GP.C/ NCW
Mitigation	No mitigation is required.

Figure 13: CO-01, open area that could indicate a past homestead

Site Name	CO-02
GPS Coordinates	26°22'11.10"S ; 28°56'36.14"E
Site Description	Grave depicted on 1965 map in a location just north of the railway line. Not confirmed on site survey
Approximate Age	If still extant, at least 58 years or older
NHRA, No. 25	Section 36
Field Grading and Ratings	
Site context and description	No signs of a grave were visible on the ground surface in the approximate location of the grave, except for an isolated stone. However, it was observed that a road had been graded immediately adjacent to the eastern boundary of the drilling site which may have obscured any signs of a grave in this location.
Site Density	At least one grave could be present, below the ground surface.
Uniqueness	Low
Heritage Significance	High - GP.A/ IIIA
Mitigation	The approximate location of the grave must be monitored during any further site clearance and preparation activities for the proposed CO2 injection site.

Figure 14: CO-02, View of the ground surface in the approximate location of the possible grave

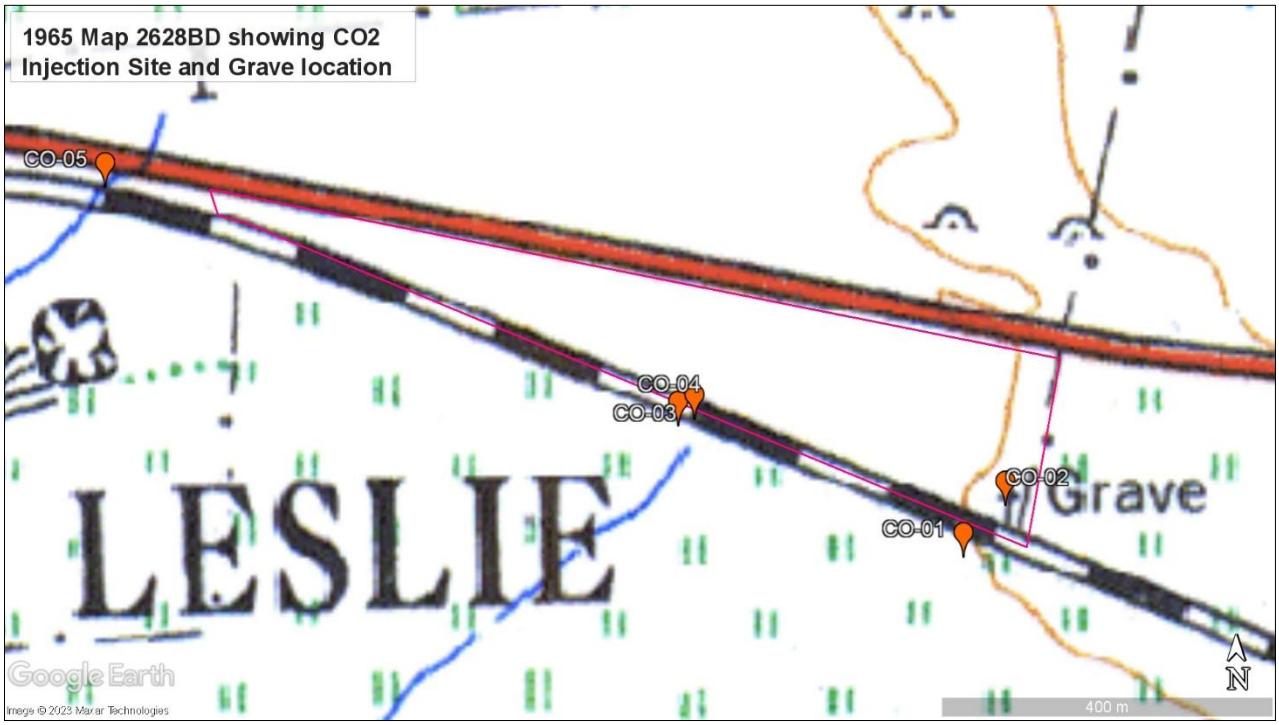

Figure 15: Enlarged view of Map sheet 2628BD Ed 1 1965, showing grave depicted at CO-02 in relation to CO2 Injection Site footprint

Figure 16: Proposed Injection Site Layout showing approximate location of the possible grave CO-02

Site Name	CO-03
GPS Coordinates	26°22'7.76"S ; 28°56'22.71"E
Site Description	Stone culvert under railway line
Approximate Age	At least 58 years or older, the railway is depicted on the 1965 map
NHRA, No. 25	Section 34
Field Grading and Ratings	
Site context and description	The site is a stone drainage culvert located under the railway line. The culvert is located just outside(4-5m) the southern boundary of the proposed injection site footprint. It is visible on satellite imagery as well as on the ground.
Site Density	One
Uniqueness	Rare
Heritage Significance	High – Such structures have been rated as Grade II of Provincial Heritage Significance in Fisher and Clarke's (2016) extensive survey of extant NZASM structures.
Mitigation	Structure to be avoided with a buffer of at least 10-20m, especially on the northern side of the railway, where the injection drill site is proposed to be located.

Figure 17: View of the stone culvert under the railway line at CO-03. This seems to be an example of a flat lintel or box culvert.

Figure 18: Close-up satellite view of the location of CO-03

Site Name	CO-04
GPS Coordinates	26°22'8.01"S ; 28°56'22.01"E
Site Description	Possible remains of structure.
Approximate Age	Unknown. No structure is depicted on the 1965 map
NHRA, No. 25	N/A
Field Grading and Ratings	
Site context and description	The site is the possible remains of a structure and consists of scattered building rubble with an old cement post.
Site Density	N/A
Uniqueness	Low
Heritage Significance	Low - GP.C/ NCW
Mitigation	No mitigation is required.

Figure 19: View of the building rubble at CO-04

Site Name	CO-05
GPS Coordinates	26°21'58.78"S, 28°55'57.26"E
Site Description	Historical stone railway culvert
Approximate Age	At least 58 years or older, the railway is depicted on the 1965 map
NHRA, No. 25	Section 34
Field Grading and Ratings	
Site context and description	The site is a stone drainage culvert located under the railway line. This seems to be an example of a flat lintel or box culvert. The culvert is located a short distance (130m) outside the western end of the CO2 Injection site footprint. It is visible on satellite imagery as well as on the ground.
Site Density	N/A
Uniqueness	Rare
Heritage Significance	High - Such structures have been rated as Grade II of Provincial Heritage Significance in Fisher and Clarke's (2016) extensive survey of extant NZASM structures.
Mitigation	Structure to be avoided with a buffer of at least 10-20m

Figure 20: View of historical stone culvert under railway line at CO-05

Figure 21: Closer view of the stone culvert

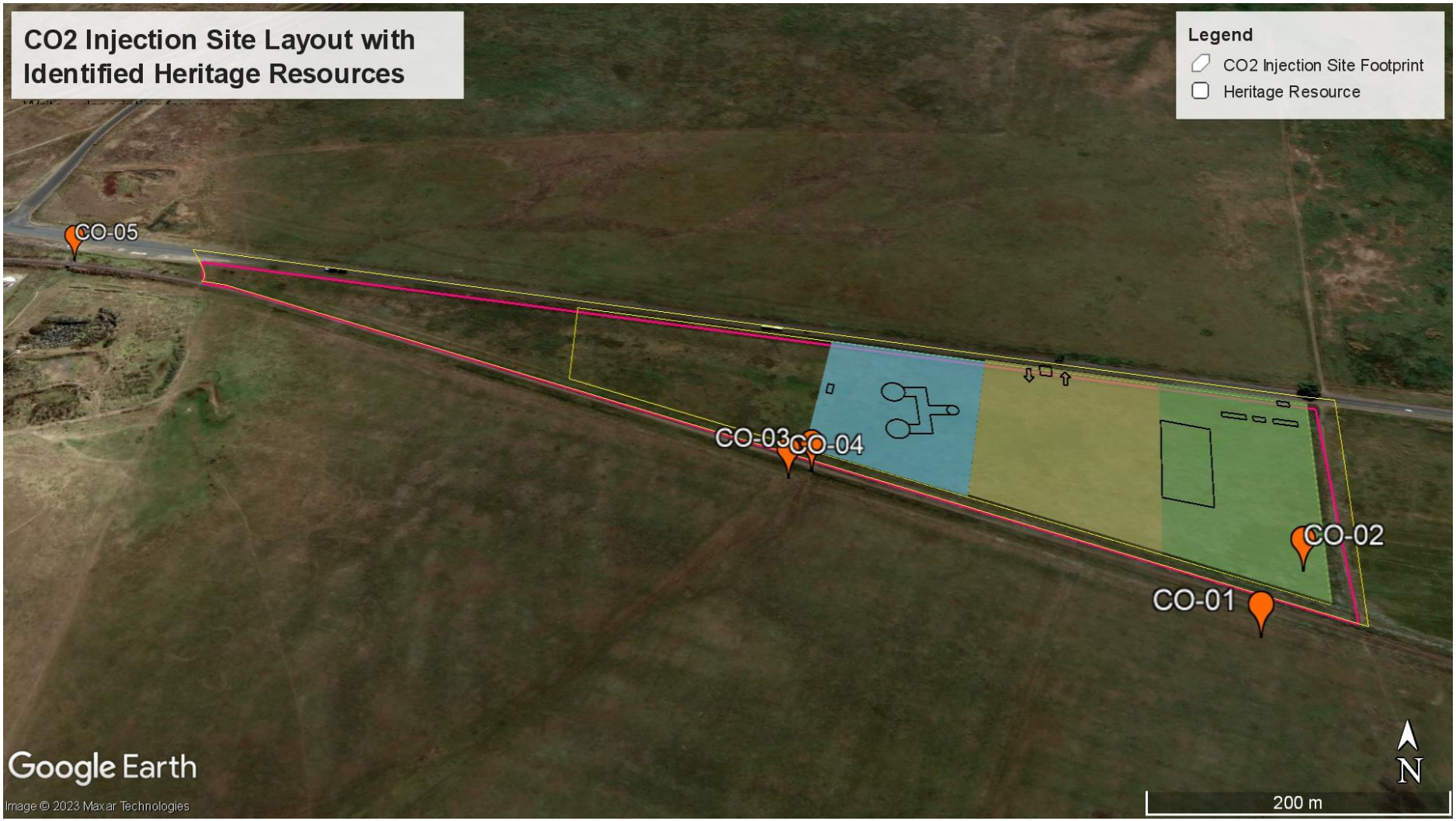

Figure 22: Enlarged satellite view of the proposed CO2 Injection Site footprint showing the five Identified Heritage Sites

Figure 23: Site Survey Tracklog overlaid on the CO2 Injection Site footprint.

7 SIGNIFICANCE ASSESSMENT

Methodology for Assessing Heritage Site Significance

The applicable maps, tables and figures are included, as stipulated in NHRA and NEMA. The HIA process consists of three steps:

Literature Review

The desktop literature review provided information on the Heritage Background of the general region and project area. This included investigating published sources as well as past HIA studies conducted for the project area and surrounding region. An examination of historical 1:50 000 topographical maps and/or archival maps (if available) was also undertaken. The relevant early editions of the 2628BD topographical map sheets were obtained from the Department of Agriculture, Land Reform & Rural Development (DALRRD), Cape Town. A number of internet sites were also accessed for information.

Literature resources accessed are listed in Table 3.

Table 3: Literature sources accessed

Source	**Information**
Background Information Document - Nemai	Project location and description details
Published sources and Past HIAs	Historical and archaeological background on Leandra/Leslie as well as surrounding region
Directorate: National Geo-spatial Information of the Department of Agriculture, Land Reform & Rural Development, Cape Town	Historical topographic maps, 1:50 000 2628BD Leslie Edition 1 1965

Field Survey

A physical Site Inspection or Field Survey was conducted, predominantly on foot for the Injection Site but with a combination of vehicle and pedestrian access for the larger surrounding area, by an experienced heritage specialist, as part of a specialist team. This focussed on identifying and documenting heritage resources situated within and immediately adjacent to the proposed Injection Site footprint, such as graves, historical structures or remains and archaeological sites or material.

HIA Report

The final step involved the recording and documentation of the identified heritage resources, the assessment of such resources in terms of heritage significance and impact assessment criteria, producing a heritage sensitivity map and compiling the heritage impact assessment report with constructive recommendations for mitigation, if required.

Impacts on these sites by the development will be evaluated as follows:

Site Significance

Site significance classification standards use is based on the heritage classification of s3 in the NHRA and developed for implementation keeping in mind the grading system approved by SAHRA for archaeological impact assessments. The update classification and rating system as developed by Heritage Western Cape (2021) is implemented in this report.

Site significance classification standards prescribed by the Heritage Western Cape Guideline (2016), were used for the purpose of this report **Table 4** and **Table 5**).

Table 4: Rating system for archaeological resources

Grading	Description of Resource	Examples of Possible Management Strategies	Heritage Significance
I	Heritage resources with qualities so exceptional that they are of special national significance. Current examples: Langebaanweg (West Coast Fossil Park), Cradle of Humankind	May be declared as a National Heritage Site managed by SAHRA. Specific mitigation and scientific investigation can be permitted in certain circumstances with sufficient motivation.	Highest Significance
II	Heritage resources with special qualities which make them significant, but do not fulfil the criteria for Grade I status. Current examples: Blombos, Paternoster Midden.	May be declared as a Provincial Heritage Site managed by Provincial Heritage Authority. Specific mitigation and scientific investigation can be permitted in certain circumstances with sufficient motivation.	Exceptionally High Significance
III	Heritage resources that contribute to the environmental quality or cultural significance of a larger area and fulfils one of the criteria set out in section 3(3) of the Act but that does not fulfil the criteria for Grade II status. Grade III sites may be formally protected by placement on the Heritage Register.		
IIIA	Such a resource must be an excellent example of its kind or must be sufficiently rare. Current examples: Varschedrift; Peers Cave; Brobartia Road Midden at Bettys Bay	Resource must be retained. Specific mitigation and scientific investigation can be permitted in certain circumstances with sufficient motivation.	High Significance
IIIB	Such a resource might have similar significances to those of a Grade III A resource, but to a lesser degree.	Resource must be retained where possible where not possible it must be fully investigated and/or mitigated.	Medium Significance
IIIC	Such a resource is of contributing significance.	Resource must be satisfactorily studied before impact. If the recording already done (such as in an HIA or permit application) is not	Low Significance

Grading	Description of Resource	Examples of Possible Management Strategies	Heritage Significance
		sufficient, further recording or even mitigation may be required.	
NCW	A resource that, after appropriate investigation, has been determined to not have enough heritage significance to be retained as part of the National Estate.	No further actions under the NHRA are required. This must be motivated by the applicant or the consultant and approved by the authority.	No research potential or other cultural significance

Table 5: Rating system for built environment resources

Grading	Description of Resource	Examples of Possible Management Strategies	Heritage Significance
I	Heritage resources with qualities so exceptional that they are of special national significance. Current examples: Robben Island	May be declared as a National Heritage Site managed by SAHRA.	Highest Significance
II	Heritage resources with special qualities which make them significant in the context of a province or region, but do not fulfil the criteria for Grade I status. Current examples: St George's Cathedral, Community House	May be declared as a Provincial Heritage Site managed by Provincial Heritage Authority.	Exceptionally High Significance
II	Such a resource contributes to the environmental quality or cultural significance of a larger area and fulfils one of the criteria set out in section 3(3) of the Act but that does not fulfil the criteria for Grade II status. Grade III sites may be formally protected by placement on the Heritage Register.		
IIIA	Such a resource must be an excellent example of its kind or must be sufficiently rare. These are heritage resources which are significant in the context of an area.	This grading is applied to buildings and sites that have sufficient intrinsic significance to be regarded as local heritage resources; and are significant enough to warrant that any alteration, both internal and external, is regulated. Such buildings and sites may be representative, being excellent examples of their	High Significance

Grading	Description of Resource	Examples of Possible Management Strategies	Heritage Significance
		kind, or may be rare. In either case, they should receive maximum protection at local level.	
IIIB	Such a resource might have similar significances to those of a Grade III A resource, but to a lesser degree. These are heritage resources which are significant in the context of a townscape, neighbourhood, settlement or community.	Like Grade IIIA buildings and sites, such buildings and sites may be representative, being excellent examples of their kind, or may be rare, but less so than Grade IIIA examples. They would receive less stringent protection than Grade IIIA buildings and sites at local level.	Medium Significance
IIIC	Such a resource is of contributing significance to the environs These are heritage resources which are significant in the context of a streetscape or direct neighbourhood.	This grading is applied to buildings and/or sites whose significance is contextual, i.e., in large part due to its contribution to the character or significance of the environs. These buildings and sites should, as a consequence, only be regulated if the significance of the environs is sufficient to warrant protective measures, regardless of whether the site falls within a Conservation or Heritage Area. Internal alterations should not necessarily be regulated.	Low Significance
NCW	A resource that, after appropriate investigation, has been determined to not have enough heritage significance to be retained as part of the National Estate.	No further actions under the NHRA are required. This must be motivated by the applicant and approved by the authority. Section 34 can even be lifted by the PHRA for structures in this category if they are older than 60 years.	Not Conservation worthy – no research potential or other cultural significance

Table 6: Site significance classification standards as prescribed by SAHRA.

FIELD RATING	GRADE	SIGNIFICANCE	RECOMMENDED MITIGATION
National Significance (NS)	Grade 1	Very High - of National Significance	Conservation; National Site nomination
Provincial Significance (PS)	Grade 2	Very High – of Provincial Significance	Conservation; Provincial Site nomination
Local Significance (LS)	Grade 3A	High Significance	Conservation; Mitigation not advised
Local Significance (LS)	Grade 3B	High Significance	Mitigation (Part of site should be retained)
Generally Protected A (GP.A)		High / Medium Significance	Mitigation before destruction
Generally Protected B (GP.B)		Medium Significance	Recording before destruction
Generally Protected C (GP.A)		Low Significance	Destruction

8 IDENTIFICATION OF IMPACTS

8.1 Impacts and Mitigation Framework

Each potential impact will be identified by its root cause (the project activity or action) that will result in an impact (change of the current conditions, both positive and negative) on a receptor (environmental aspect that will be affected). The potential impact will be defined as either a positive impact (benefit) or a negative impact. In addition, the impact will be defined as Direct or Indirect, and, if pertinent, cumulative.

The methodology to assess the environmental and social impacts significance includes:

- Defining the nature of the potential impact;
- Rating of the potential impact;
- Determining the overall significance of the impact

8.1.1 Defining the nature of the potential impact

Terms for defining the nature of an impact are presented in the following table.

Table 7: Definition of impact nature

Term	Definition
Positive Impact (Benefit)	An impact that is considered to represent an improvement on the baseline or introduces a positive change
Negative Impact	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor
Direct Impact	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (e.g., between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality)
Indirect Impact	Impacts that result from other activities that are encouraged to happen because of the Project (e.g., in-migration for employment placing a demand on resources)
Cumulative Impact	Impacts that act together with other impacts (including those from concurrent or planned future third-party activities) to affect the same resources and/or receptors as the Project

8.1.2 Rating of the potential impact

Each potential impact will be rated based on a set of criteria, including its spatial and temporal scales, intensity, and probability (see tables below). For each criteria a scale will be used ranging from no or negligible impact to major impacts. The magnitude of the impact is a function of these criteria.

Table 8: Definition of impact magnitude

Impact Magnitude – The degree of change brought about in the environment	
Extent	• On-site – impacts that are limited to within the site boundaries; • Local – impacts that affect an area in a radius of 2 km around the site; • Regional – impacts that affect regionally important resources or are experienced at a provincial or regional scale; • National – impacts that affect nationally important resources or affect an area that is nationally important/ or have macroeconomic consequences; • Transboundary/International – impacts that extend beyond country borders or affect internationally important resources
Duration	• •Temporary – impacts are predicted to be of short duration and intermittent/occasional;

	• Short-term – impacts that are predicted to last only for the duration of the construction period; • Long-term – impacts that will continue for the life of the Project, but ceases when the Project stops operating; • Permanent – impacts that cause a permanent change in the affected receptor or resource (e.g., removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime
Intensity	**Biophysical environment** – intensity can be considered in terms of the sensitivity of the receptor; • Negligible – the impact is not detectable; • Low – the impact affects the environment in such a way that natural functions and processes are not affected; • Medium – where the affected environment is altered but natural functions and processes continue, albeit in a modified way; • High – where natural functions or processes are altered to the extent that it will temporarily or permanently cease
	Socio-economic environment – intensity can be considered in terms of the ability of project affected people/communities to adapt to changes brought about by the project: • Negligible – there is no perceptible change to people's livelihood or health; • Low – people/communities can adapt with relative ease and maintain pre-impact livelihoods and health; • Medium – able to adapt with some difficulty and maintain preimpact livelihoods and health but only with a degree of support; • High – those affected will not be able to adapt to changes and continue to maintain-pre impact livelihoods and health

Table 9: Definition of impact probability

Impact Probability – The likelihood that an impact will occur	
Unlikely	The impact is unlikely to occur
Likely	The impact is likely to occur under most conditions
Definite	The impact will occur

8.1.3 Determination of the overall significance of the impact

Once a rating is determined for magnitude and likelihood, Table 42 can be used to determine the significance of the impact. An impact may be negative or positive and therefore the final significance rating is colour coded as seen in the table below.

Table 10: Definition of impact significance

Significance Definitions	
Null or Negligible	An impact of negligible significance is where a resource or receptor will not be affected in any way by a particular activity, or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels
Low Significance	An impact of low significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value
Moderate Significance	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is As Low as Reasonably Practicable (ALARP). This does not necessarily mean that "moderate" impacts must be reduced to "low" impacts, but that moderate impacts are being managed effectively and efficiently
High Significance	An impact of high significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. A goal of the ESIA process is to get to a situation where the project does not have any high residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be high residual impacts after all practicable mitigation options have been exhausted (i.e., ALARP has been applied). An example might be the visual impact of a development. It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the Project.

Table 11: Significance colour codes

Colour codes for the significance classification used in the impact assessment		
Negative	**Significance**	**Positive**
	Null or Negligible	
-	Low	**+**
-	Moderate	**+**
-	High	**+**

8.1.4 Determination of the risk level

The Project risks will be classified according to the following matrix:

Table 12: Definition of the risk level

Determination of the risk level			
Severity (Significance)	**Likelihood (Probability)**		
	Unlikely	**Likely**	**Definite**
High	Moderate	High	Very High
Moderate	Low	Moderate	High
Low	Low	Low	Moderate
Negligible	Acceptable	Acceptable	Acceptable

Generally, impacts of negligible or low significance are acceptable. Impacts of moderate or high significance require mitigation and impacts of high significance may be classified as unacceptable.

Detailed impact description, justification, and assessment for the considered environmental and social factors are presented below.

The proposed Project footprint was found to contain five heritage resources.

The impact significance of the proposed CO2 Injection Site on protected historical structures is Low. Two extant historical structures and two sites with possible historical structure remains were identified, either on or just outside the southern boundary of the proposed Injection Site footprint.

The impact significance of the project on graves and cemeteries is Low. One potential grave site was identified as possibly located within or just outside the eastern boundary of the proposed Injection site footprint.

The impact significance of the project on intangible and living heritage resources is negligible as no living heritage sites were identified within or adjacent to the proposed Injection site footprint.

The impact significance of the proposed project on archaeological resources is negligible to low as no archaeological sites or material were identified within or adjacent to the proposed Injection site footprint.

8.2 Impacts During the Construction, Operation and Decommissioning Phases

As a result of the analysis above, the following impact/mitigation tables have been generated.

Construction Phase

Table 13: Construction phase impacts on Heritage Resources Historical Structures

Dimension	Assessment
Signal	Negative
Directionality	Indirect
Extent	On-site
Duration	Permanent
Intensity	High
Probability	Likely
Significance (without mitigation)	High
Significance (with mitigation)	Low
Mitigation	• A buffer of at least 20-30m must be placed around the railway culvert to ensure that during the construction phase, this structure is not damaged. • The materials demarcating the 30m buffer must be highly visible and made of durable material to ensure that they are still in place during the construction phase.

Table 14: Construction phase impacts on Heritage Resources Potential Grave/s

Dimension	Assessment
Signal	Negative
Directionality	Direct
Extent	On-site
Duration	Permanent
Intensity	High
Probability	Likely
Significance (without mitigation)	High
Significance (with mitigation)	Low
Mitigation	• At the onset of any site clearance activities for the proposed injection site construction, a walk-down of the area must be undertaken by a heritage specialist to monitor any unidentified grave sites. • If an unidentified grave site is uncovered during site clearance or construction activities, a buffer of at least 30m

	must be placed around the site to ensure that during construction, the grave/s are not damaged.

The operational and decommissioning phases of the project are not expected to affect the identified heritage resources, with no positive or negative impacts to be considered.

8.3 Cumulative Impacts

The project area and surrounding region has been affected by impacts of activities occurring in the past, current activities and proposed future developments. These will be discussed below.

Past impacts: several development and other activities in the past would have disturbed the heritage resources which occur in the area. This includes the initial establishment and development of the town of Leslie/Leandra and the associated township of Lebohang, the construction of the railway and R29 regional road and the R50 road, as well as historical agricultural activities. The past HIA reports recovered from the SAHRIS database also indicate that the surrounding region has been affected by various previous developments, which include coal, gold and gravel mining activities as well as the development of an existing quarry and golfcourse.

Current impacts: the immediate area of the project footprint is affected by existing residential and business/commercial built environment as well as farming activities.

The baseline impacts for the project area are considered to be low to moderate for Heritage resources, and additional project impacts (if no mitigation measures are implemented) will increase the significance of the existing baseline impacts, where the cumulative unmitigated impact will probably be of a moderate significance. The impact is going to happen and will be short-term in nature, therefore the impact risk class will be Low to Moderate. However, with the implementation of the recommended management and mitigation measures this risk class can be minimized to a Low rating.

9 Analysis of Alternatives

This project is intended to be a research project for the piloting of CCS in South Africa and the study area was identified specifically due to the suitability of the geological formations that exist in the Leandra area. Therefore, no alternatives are proposed.

10 ALTERNATIVES

10.1 Introduction

Alternatives are the different ways in which the Project can be executed to ultimately achieve its objectives. Examples could include carrying out a different type of action, choosing an alternative location or adopting a different technology or design for a project.

10.2 Site / Land-use Alternatives

Overall, the present project is identified as an investigation project to assess the CCS technology. The preferred site was strategically selected by the project developer based on the following considerations:

- The Mpumalanga Province has the presence of mining and petrochemical industrial activities that are identified as responsible for high levels of CO2 emissions, being the project area is located near to a major polluter;
- The project area is characterized by a basaltic geological nature with Storage potential; and
- The project area is under the ownership of the Gert Sibande District Municipality and currently without any human use.

The project area is located in a Grassland Biome, the second largest in South Africa, covering 28.4% of the land area. Moreover, most of the area is covered by dolerite, comprising black clay soil underlain by shale and fine sandstone. The municipal area of development is semi-urban, consisting of farms and urban settlements and being located between a main road and a railway, without any current agricultural use.

For further understanding, below are summarized major factors that led to preferred site selection:

- Land Availability: The proposed project site has approximately 14 ha of area, which is suitable for the proposed activities. The area will allow for the inclusion of all the necessary facilities;
- Biodiversity Sensitivity: The proposed project site, although it interferes with the natural ecosystem and biodiversity of the area, does not contain any high sensitivity in the area (according to the Screening Tool information;
- Site Accessibility: The proposed project site is bounded by the Provincial Route R29, which will be used as direct access. No extra access will be required;
- Geology: The project area has in its geological profile the formation that has been studied as potential for CO2 storage - the Ventersdorp Ultramafic lavas;
- Current Land Use: No current use;
- Landowner Willingness: The Gert Sibande District Municipality, as landowner, has granted access and use of this land for the purposes of the project; Furthermore, the proposed site is

located approximately more than 800m from the nearest residential house, which is also considered a positive factor

10.3 Layout / Design Alternatives

The characteristics of the preferred site and the infrastructures required to implement the project must be considered.

Project components (infrastructures required). As identified before, overall, the main project components are: perimeter fencing; access road inside the area and parking area; power transformers/generators; portable temporary storage facilities; shelter for security personnel; mobile offices; concrete pads for two CO2 Cryogenic Storage Tanks (100 tons each); geological survey; injection well; and storage area for diesel, oils, spare parts, drilling rods

Preferred site characteristics: with an area of approximately 14 ha, the proposed injection site is located between a Provincial Route (which will be used as access), and a railway route, forming a triangular area.

Given the project area and the main infrastructures required, an implementation area was defined based on the proposition:

- The creation of a suitable area to allocate all the necessary infrastructure and considering a defense zone, taking into consideration, 20 metres in relation to the left edge of the area, and 10 meters in relation to the road and railway line.

This then guided the selection of the best suitable developable footprint to be assessed, in this phase, by the specialists from an environmental sensitivity and practical/ technical perspective.

In addition to the definition of the implementation area, a preliminary area of potential Direct and Indirect influence of the project was also defined for the environmental footprint analysis. These areas have been defined to ensure an overview of the possible influence of the project. Given the information above, no other alternative development footprints within the preferred project site will be considered.

10.4 Technology Alternatives

For the understanding of the proposed injection technologies, it is first necessary to analyse the storage process in basaltic formations.

10.4.1 CCS in Basalt

About 60% of the earth's surface comprises basaltic rocks. This means that there are potentially options for geological storage, including large volumes (Nemus 2023). The implementation of CCS technology in basaltic formations has been proven to be feasible through two pilot projects successfully completed - CarbFix at the Hellisheidi geothermal power plant in Iceland and Wallula in

the Columbia River plateau, in the United States (Nemus 2023). Through this type of storage, it is expected that once it has been precipitated the CO2 capture will be permanent. Moreover, mineral carbonation in basaltic formations has been seen to occur over the timescale of weeks to months, which represents an advantage over, for example, capture in sedimentary environments. This highlights the potential of long-term geological storage, and permanent fixation of carbon by mineralization.

10.4.2 Basaltic CO2 Injection

The injection technology possibilities analysed in the Project are directly related to the two pilot projects successfully developed in Iceland and the USA. The Carbfix project in Iceland has injected dissolved CO2 in water into young basaltic units. The Big Sky Carbon Sequestration Partnership (BSCP) in Wallula, Washington, USA, injected supercritical CO2 into a porous basaltic layer within the Columbia River flood basalt province (U.S. Department of Energy, 2013). **Figure 24** and **Figure 25** shows a schematic representation of both technologies.

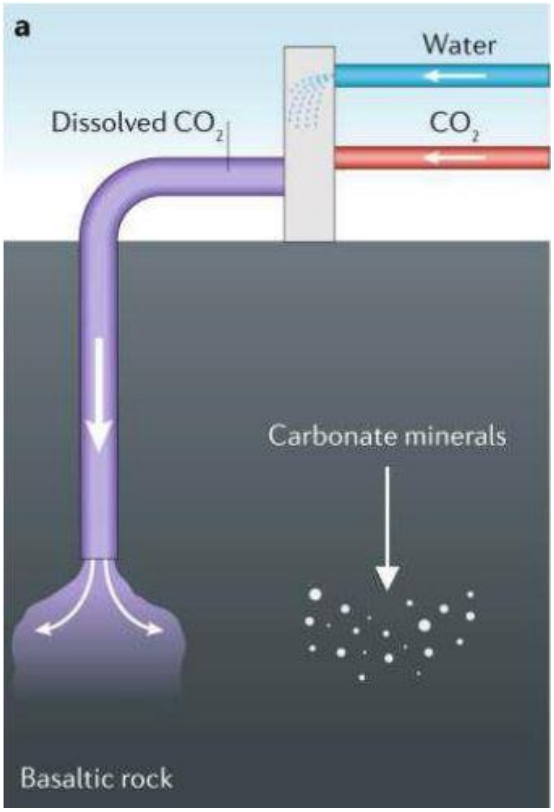

Figure 24: Injection of dissolved CO2 into a basaltic reservoir

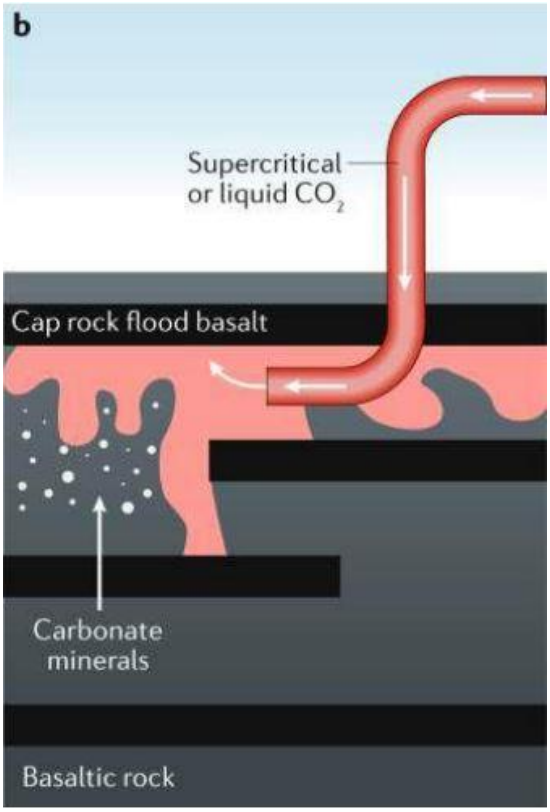

Figure 25: Injection of pressurized liquid CO2 injected into a basaltic reservoir

10.4.3 Injection of water-CO2 solution

Through this technology, carbonization occurs when soluble CO2 in water reacts with mafic or ultramafic formations. Overall, the acid solution generated by the combination of carbon dioxide and water reacts with the rock, namely with divalent cations leading to the precipitation of carbonate minerals and to the occurrence of the mineralization process (Nemus 2023). According to the Carbfix project, CO2 concentrations should be kept below its solubility at reservoir conditions to reduce the risk of degassing and to allow immediate reaction with the reservoir rocks.

Although the water requirement for the implementation of the project is dependent on the average pressure, temperature, and salinity of the injection fluid, in general, this method requires a large amount of water, ~25 tonnes are required for each tonne of gas injected to fully dissolve the CO2. Consequently, it is necessary to identify a source of water with sufficient volume & quality, preferably saline, and the requisite environmental and water permits obtained for its use in the water charged CO2 injection system. However, in accordance with the "Carbon Capture, Utilization and Storage (CCUS): Project Progress Report for Geological CO2 Storage in the Ventersdorp Supergroup, Mpumalanga, South Africa", the water to be used could be sourced from the target injection reservoir. Therefore, it is possible to provide access for monitoring the chemistry of the injected gas- charged fluid and preventing pressure build- up in the reservoir owing to injection.

Compared to the injection of supercritical CO2 technology, a dissolved stream is denser and therefore buoyancy problems and the need for specific sealing structures are neglected. Dissolved CO2 flow can be injected into fractured and even open aquifers if the flow path is long enough to generate alkalinity and eventually mineralize the CO2 (Nemus 2023). The implementation of this method leads to rapid mineralization, Carbfix project reported >95% of the injected gas mineralized within 2 years. Briefly, this method of dissolving CO2 before and during injection into an acidic medium result in a significantly reduced time scale for mineral storage process, with solubility trapping occurring immediately, and thus CO2 is immobile and deemed stored on geological time scales

10.4.4 Injection of supercritical CO2

Supercritical CO2 means the carbon dioxide is in a fluid state while at or above both its critical temperature and pressure (Nemus 2023). According to U.S Department, the temperature should exceed 31.1°C (88ºF) and pressure 72.9 atm (about 1,057 psi). Once these conditions are fulfilled, CO2 reaches a critical point of properties where it has the density of a liquid with the viscosity of a gas. The main advantage of this condition is that the required storage volume is substantially less than if the CO2 were at "standard" conditions (Nemus 2023). Temperature naturally increases in depth, and therefore an increase in fluid pressure also occurs. At depths greater than 800 metres it is expected to reach the CO2 critical point of pressure and temperature (Nemus 2023). As the injection borehole to be developed under this project is at a depth of approximately 1,800 metres, this means that it is expected that the CO2, once injected, will remain in the same supercritical condition. Considering its characteristics, the Supercritical CO2 should be provided in tanks, and the gas stream heated and pressurized before injection. Most underground carbon dioxide storage projects are developed by

implementing this methodology, but into large sedimentary basins. Although there are projects implementing this method and with larger amounts of injected CO2 (as is the case with the Sleipner project, west of Norway - where about one million tons of CO2 has been injected annually since 1996), the major difference is in the timescale of the mineralization process (Nemus 2023). According to the Wallula Basalt Pilot, monitoring results revealed that much of the CO2 were mineralized by the end of 24 months after injection. Therefore, as the dissolved CO2 injection methodology, this method also demonstrated potential for rapid in-situ carbonation occurring from a free phase supercritical CO2 injection into a flood basalt reservoir.

As both technologies are still under research and in need of data evaluation there is currently no preferable alternative.

10.5 No-Go Option

As standard practice and to satisfy regulatory requirements, the option of not proceeding with the Project is included in the evaluation of the alternatives.

The no-go alternative can be regarded as the baseline scenario against which the impacts of the Project are evaluated. This implies that the current status and conditions associated with the proposed Project footprint will be used as the benchmark against which to assess the possible changes (impacts) associated with the Project.

If the project does not proceed, the following consequences stand out:

- No benefits will be derived from the implementation of an additional landuse;
- No opportunity for additional employment in an area, where job creation is a priority;
- No opportunity for a further understanding of the site potential for the CO2 Storage;
- No contribution to and assist the government to achieve its commitment to implement climate change mitigation measures;
- No opportunity to contribute to achieving the government target for reducing carbon dioxide emissions;
- No opportunity to implement a pilot technology and contribute to the research currently being carried out at national level;
- No opportunity to implement a mitigation measure recognized by NAMA; and
- No opportunity to have positive impacts on local people and surrounding ecosystems by being able to capture CO2 that would otherwise go into the atmosphere.

On the other hand, the benefits of the no-go alternative should also be indicated, namely:

- No surface or underground water will be disturbed;
- No negative impacts on the natural rock mass matrix;
- No vegetation will be disturbed;
- No noise impacts will occur, mainly during the construction phase (when the drilling operation is occurring);

- No additional traffic will be generated; and
- No additional water use and energy will be required.

Despite not having negative environmental impacts in the area, the no-go alternative means that no additional contribution will be made to the CCUS technology investigations and no additional studies regarding the carbon dioxide storage capacity of geological formations in basaltic sequences of the Ventersdorp Supergroup. Furthermore, it will not have any positive community development or socio-economic benefits, and it will not assist the government addressing the climate change. Besides, it is an area without any current human use and is under the ownership of the Gert Sibande District Municipality, which means that it is not planned to be currently used for any other activity plus, once the project is complete, the aim is to return the space to conditions close to its pre-occurrence state. Therefore, the no-go alternative is not the preferred alternative.

11 STATEMENT OF IMPACT SIGNIFICANCE

The project area that will be impacted by the CO_2 Injection Phase for the proposed Pilot Carbon Capture Underground Storage project is situated on portion 2 of the Farm Goedehoop 308IR. The proposed CO2 Injection site is located outside (to the east) of the town, between the R29 road from Leandra to Kinross and the railway line from Secunda to Springs.

The impact of the proposed project on protected historical structures is low with mitigation. Two historical stone railway culverts (CO-03, CO-05), and two possible but not certain structure or homestead remains (CO-01, CO-04) identified within and adjacent to the Injection footprint.

The impact significance of the project on graves and cemeteries is low with mitigation. A potential grave (CO-02) identified within the Injection site footprint could be affected.

The impact significance of the project on intangible and living heritage resources is negligible to low as no intangible or living heritage resources were identified.

The impact significance of the proposed project on archaeological resources is low as no archaeological sites or material were identified.

12 HERITAGE MANAGEMENT GUIDELINES

12.1 General Management Guidelines

1. The National Heritage Resources Act (Act 25 of 1999) states that, any person who intends to undertake a development categorised as-

a) the construction of a road, wall, transmission line, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;
b) the construction of a bridge or similar structure exceeding 50m in length;
c) any development or other activity which will change the character of a site-
d) exceeding 5 000 m^2 in extent; or
e) involving three or more existing erven or subdivisions thereof; or
f) involving three or more erven or divisions thereof which have been consolidated within the past five years; or
g) the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority;
h) the re-zoning of a site exceeding 10 000 m^2 in extent; or
i) any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority, must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development.

In the event that an area previously not included in an archaeological or cultural resources survey is to be disturbed, the SAHRA needs to be contacted. An enquiry must be lodged with them into the necessity for a Heritage Impact Assessment.

2. In the event that a further heritage assessment is required it is advisable to utilise a qualified heritage practitioner, preferably registered with the Cultural Resources Management Section (CRM) of the Association of Southern African Professional Archaeologists (ASAPA).

   This survey and evaluation must include:
   a) The identification and mapping of all heritage resources in the area affected;
   b) An assessment of the significance of such resources in terms of the heritage assessment criteria set out in section 6 (2) or prescribed under section 7 of the National Heritage Resources Act;
   c) An assessment of the impact of the development on such heritage resources;
   d) An evaluation of the impact of the development on heritage resources relative to the sustainable social and economic benefits to be derived from the development;
   e) The results of consultation with communities affected by the proposed development and other interested parties regarding the impact of the development on heritage resources;
   f) If heritage resources will be adversely affected by the proposed development, the consideration of alternatives; and
   g) Plans for mitigation of any adverse effects during and after the completion of the proposed development.

3. It is advisable that an information section on cultural resources be included in the SHEQ training given to contractors involved in surface earthmoving activities. These sections must include basic information on:

a. Heritage;
b. Graves;
c. Archaeological finds; and
d. Historical Structures.

This module must be tailor made to include all possible finds that could be expected in that area of construction.

Possible finds include:

a. Unidentified graves
b. Historical artefacts or material
c. Remains of historical structures
d. Palaeontological deposits

4. In the event that a possible find is discovered during construction, all activities must be halted in the area of the discovery and a qualified archaeologist contacted.
5. The archaeologist needs to evaluate the finds on site and make recommendations towards possible mitigation measures.
6. If mitigation is necessary, an application for a rescue permit must be lodged with SAHRA.
7. After mitigation, an application must be lodged with SAHRA for a destruction permit. This application must be supported by the mitigation report generated during the rescue excavation. Only after the permit is issued may such a site be destroyed.
8. If during the initial survey sites of cultural significance are discovered, it will be necessary to develop a management plan for the preservation, documentation or destruction of such a site. Such a program must include an archaeological/palaeontological monitoring programme, timeframe and agreed upon schedule of actions between the company and the archaeologist.
9. In the event that human remains are uncovered, or previously unknown graves are discovered, a qualified archaeologist needs to be contacted and an evaluation of the finds made.
10. If the remains are to be exhumed and relocated, the relocation procedures as accepted by SAHRA need to be followed. This includes an extensive social consultation process.

13 RECOMMENDATIONS AND CONCLUSION

The proposed Pilot Carbon Dioxide Storage project could impact on five heritage resources identified within or immediately adjacent to the CO2 Injection Site footprint area.

The recommendations below are provided to mitigate the potential impact of the proposed project on the identified heritage resources:

Historical structure

- **The Historical Railway Culvert at CO-03** is protected by section 34 of the NHRA and must be avoided as a "no-go" area with a 20-30m buffer to prevent any indirect impact and ensure that during site clearance and construction activities this structure is not damaged
- The materials demarcating the 30m buffer must be highly visible and made of durable material to ensure that they are remain in place during the construction and operation activities

Potential Grave

- **The potential grave at CO-02**, that may be located within or on the boundary of the proposed CO2 Injection site, is protected by section 36 of the NHRA. Therefore, any site clearance activities for the proposed Injection site within 30m of the approximate location, should be monitored by a heritage specialist/archaeologist. If a burial or human remains are uncovered during site clearance or construction activities, a buffer of at least 30m must be placed around the site to ensure that the burial/human remains are not damaged. In addition, all site clearance or construction activities in the immediate vicinity of the burial/human remains must be suspended. The heritage specialist/archaeologist will then need to apply for a permit for a rescue exhumation of the burial/human remains, in compliance with section 36 of the NHRA.

Palaeontological Heritage

- The Screening Tool identified the underlying geology of the project footprint as having a Medium sensitivity for palaeontological heritage, while the SAHRIS Palaeontological Map identified the underlying geology of the project footprint as having an Insignificant to Zero fossil sensitivity. However, SAHRA has required either a desktop or a field palaeontological assessment for past HIAs in the surrounding area.
- The assessment would confirm if it is likely that significant/sensitive fossils will be impacted by the proposed project and provide mitigation measures and the way forward in this regard. The project may only proceed once the palaeontological assessment has been undertaken and any mitigation recommendations have been implemented.

Taking all of the above into account, the considered opinion of the heritage specialist is that no fatal flaws have been identified during this study. Therefore, there are no objections from a heritage perspective provided that the recommendations and mitigation measures contained in this report and in the palaeontological assessment are implemented where necessary.

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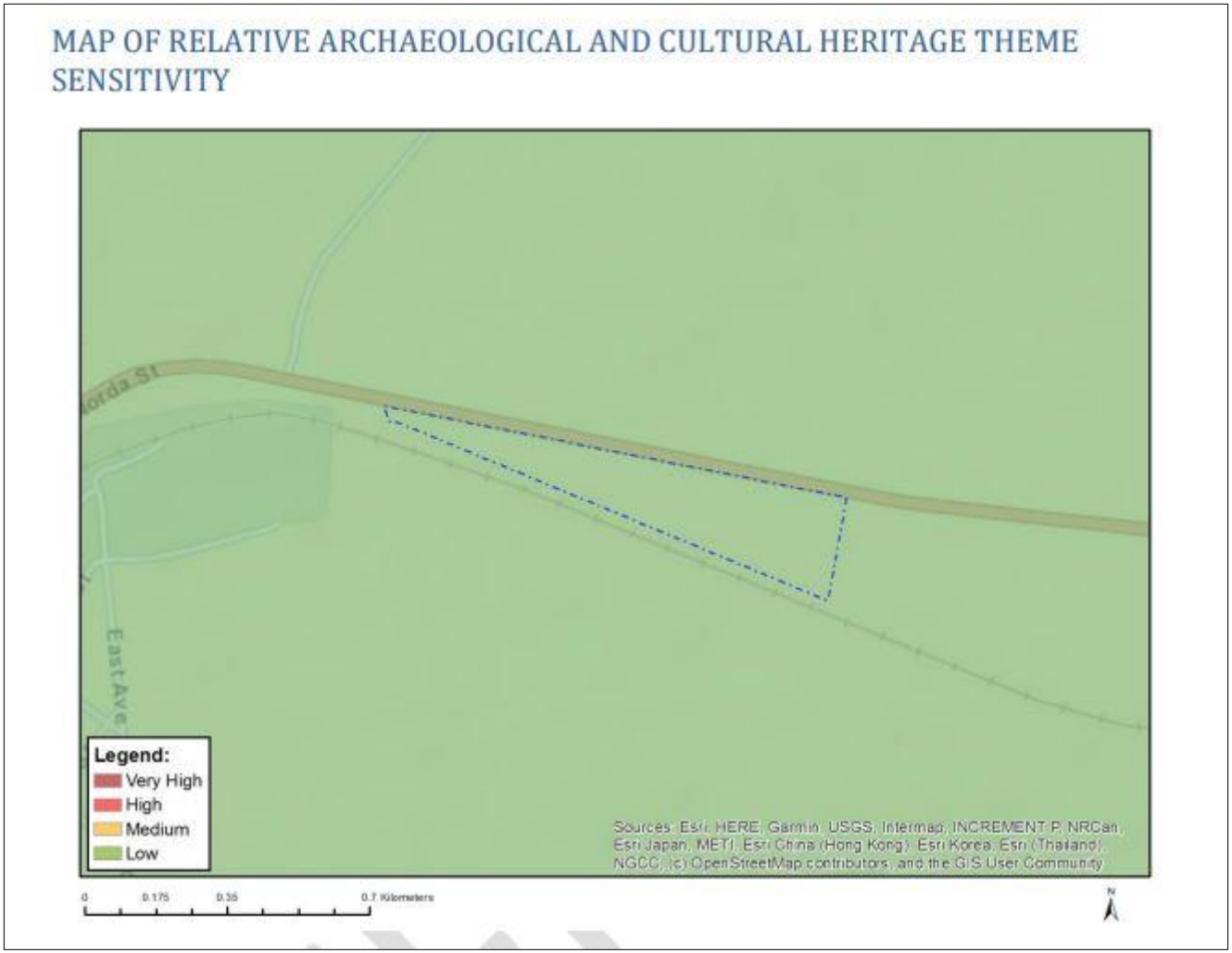
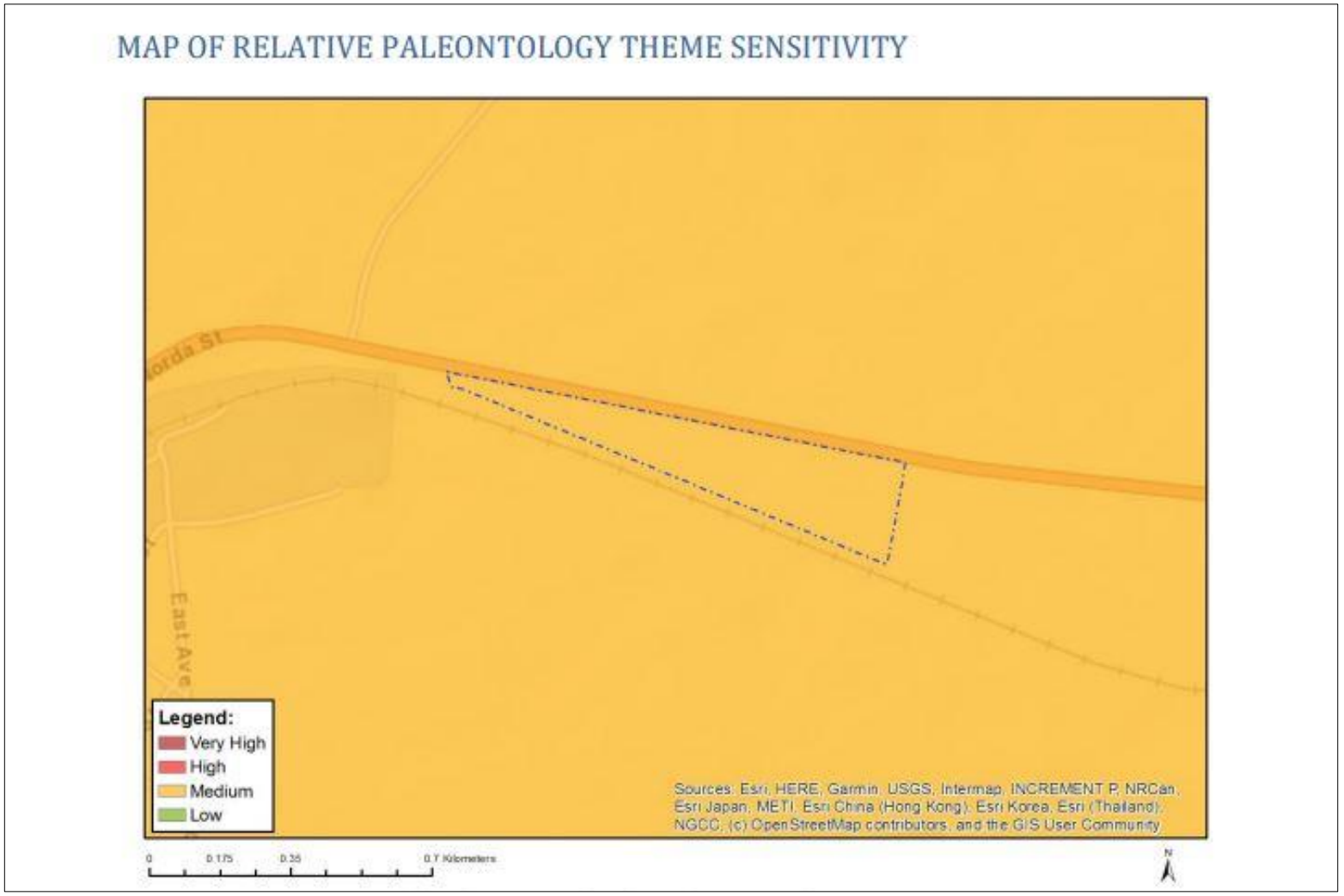
APPENDIX 1: HERITAGE SENSITIVITY MAP/S

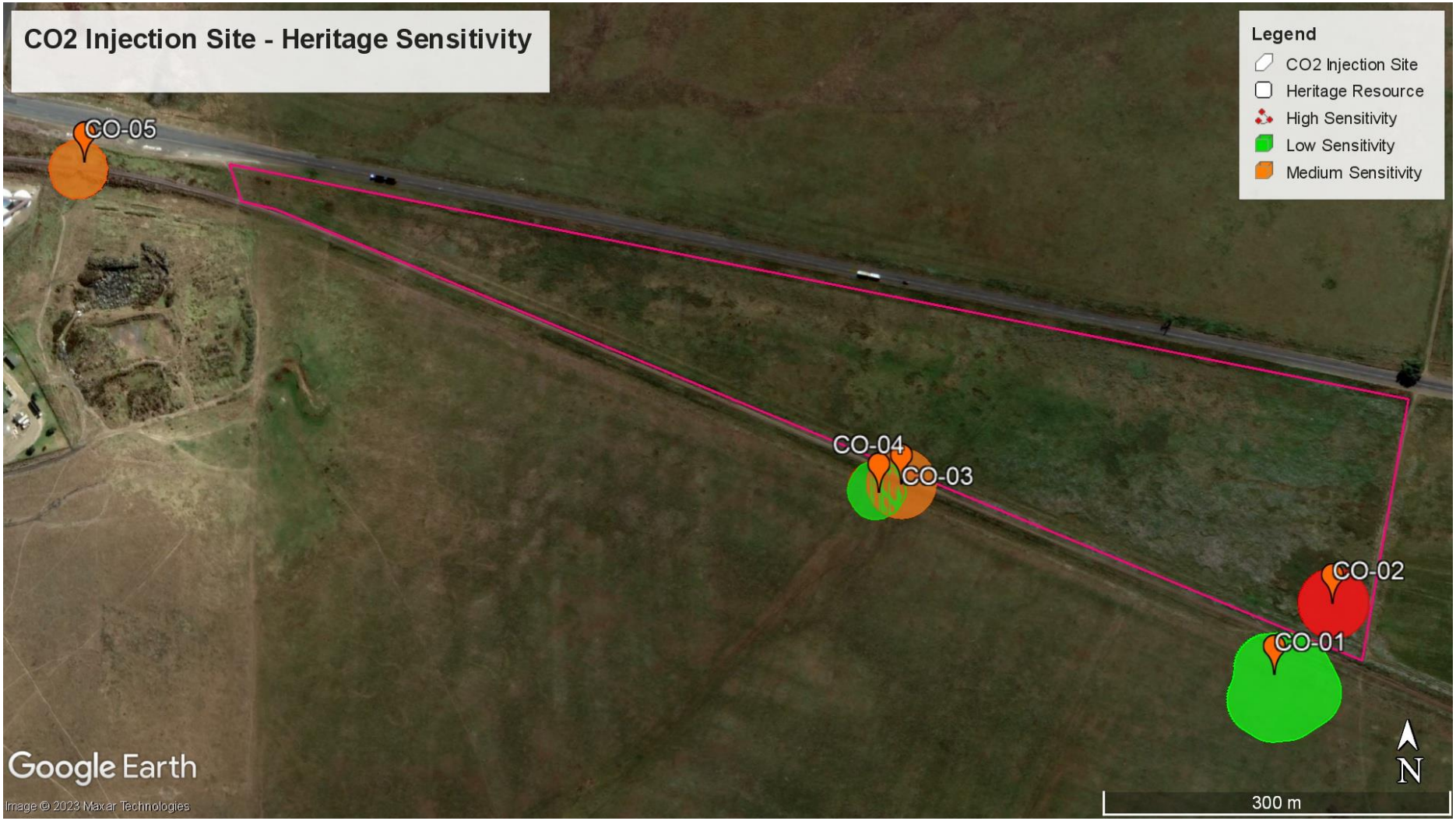
1. Cultural Heritage Sensitivity map from DFFE screening tool



2. Palaeontological Sensitivity map from DFFE screening tool



3. Heritage Sensitivity Maps based on the Site Inspection / Field survey



APPENDIX 2: CURRICULUM VITAE OF HERITAGE SPECIALIST

1 Personal Particulars

Profession:	Heritage Specialist
Date of Birth:	11 September 1966
Name of Firm:	Nitai Consulting
Name of Staff:	Jennifer Kitto
Nationality:	RSA
Membership of Professional Societies	Association of Southern African Professional Archaeologists (444); IAIAsa (7151)

2 Education:

BA Hons Social Anthropology, WITS, South Africa, 1994

BA. Archaeology and Social Anthropology, WITS,, South Africa, 1993

Higher National Diploma, Practical Archaeology, Dorset Institute for Higher Education (now Bournemouth University), UK, 1989

3 Employment Record:

2022 – Present *Heritage Specialist, Nitai Consulting*

Conduct Heritage Impact Assessments;

2012 – 2021 *Heritage Specialist, PGS Heritage (Pty) Ltd*

Conduct Heritage Impact Assessments

Compile Desktop Historical Research

Compile Heritage Audit and Management Plans

Compile and submit permit applications to National and Provincial Heritage Authorities for Section 34 building alterations and demolitions (under National Heritage Resources Act, 25 of 1999)

Compile and submit permit applications to Provincial and Municipal Health Authorities for Section 36 relocations of graves and burial grounds (under National Heritage Resources Act, 25 of 1999 and National Health Act, No 61 of 2003)

2008 – 2011 Cultural Heritage Officer (National), Burial Grounds and Graves Unit: South African Heritage Resources Agency (SAHRA)

Review and assessing permit applications for relocation of historical graves and burial grounds

1998 – 2008 Cultural Heritage Officer (Provincial), Provincial Office – Gauteng: SAHRA

Review and comment on heritage and archaeological impact reports

Research for the nomination and grading process for related to the declaration of specific heritage resources as National Heritage Sites

Monitoring of certain archaeological and built environment National Heritage Sites (e.g. The Cradle of Humankind World Heritage Site)

4 Selected Consultancies

4.1 GDID East Corridor, OHS Implementation, Tambo Memorial Regional Hospital (as sub-contractor to PGS Heritage (Pty) Ltd

2022 Independent Heritage Specialist,. Compile Historical Archival Report of Tambo Hospital Boksburg, Gauteng for PGS Heritage (Pty) Ltd, Finalise HIA Report and submit HIA report to Gauteng Provincial Heritage Resources Authority

4.2 GDID East Corridor, OHS Implementation, Tembisa Regional Hospital (as sub-contractor to PGS Heritage (Pty) Ltd

2022 Independent Heritage Specialist,. Compile Historical Archival Report of Tembisa Hospital, Ekurhuleni, Gauteng for PGS Heritage (Pty) Ltd, Finalise HIA Report and submit HIA report to Gauteng Provincial Heritage Resources Authority.

4.3 Kroonstad Solar PV Facilities

2022/2023 Heritage Specialist, Development of three Solar PV facilities near Kroonstad, Free State Province, South Africa, Identify, assess and map all heritage resources associated with the three solar PV facilities

4.4 Kroonstad South Solar PV Facilities

2022/2023 Heritage Specialist, Development of five Solar PV facilities near Kroonstad, Free State Province, South Africa, Undertake Heritage Impact Assessment of all heritage resources associated with the five solar PV facilities

4.5 Rustenburg Solar PV Facilities

2022/2023 Heritage Specialist, Development of three Solar PV facilities near Rustenburg, North West Province, South Africa, Undertake Heritage Impact Assessment all heritage resources associated with the three solar PV facilities.

4.6 Seelo Solar PV Facilities

2022/2023 Heritage Specialist, Development of three Solar PV facilities near Carletonville, North West Province, South Africa, Undertake Heritage Impact Assessment all heritage resources associated with the three solar PV facilities.

4.7 Decommissioning of Komati Power Station

2023, Heritage Specialist, Proposed Decommissioning of the Komati Power Station, Middelburg, Mpumalanga, Undertake Heritage Impact Assessment of all heritage structures within the power station

5 Languages:

English - excellent speaking, reading, and writing

Afrikaans –fair speaking, reading and writing